CHAPTER - IV

LITHIUM CHLORIDE IN UREA-WATER SYSTEM

CONDUCTIVITY

RESULTS AND DISCUSSION

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RESULTS :

The conductivity of lithium chloride solution in 0%, 5%, 10% and 20% by weight of urea in urea-water binary mixtures were determined at 293°K, 298°K, 303°K and 308°K.

The concentration range for Lithium chloride was studied from 0.008 M to 2.0 M. Experiments were designed to include the following studies :

1) Effect of concentration of lithium chloride on conductivity.
2) Effect of urea percentage on conductivity.
3) Effect of temperature on conductivity.
4) Applications of different equations of conductivity.

4.1 EFFECT OF CONCENTRATION OF LITHIUM CHLORIDE ON CONDUCTIVITY :

The results on the effect of variation of Lithium chloride concentration (0.008 M to 2.0 M) in 5% urea-water solution at 298°K is given in table 4.2.

For the sake of convenience, the results have been divided into three parts :

1) Low concentration range from 0.008 M to 0.1 M of LiCl.
2) Moderate concentration range from 0.2 M to 0.5 M of Lithium chloride.
3) High concentration range of Lithium chloride from 0.75 M to 2.0 M.

It can be seen from the table 4.2 that at 298°K for dilute solutions (0.008 M to 0.1 M) the equivalent conductivity (Λ_c) changes from 99.50 ohm^{-1}cm^2 to 62.379 ohm^{-1}cm^2; while at moderate concentration i.e. (0.2 M to 0.5 M) it decreases from 55.63 ohm^{-1}cm^2 to 38.97 ohm^{-1}cm^2 in the high concentration range the Λ_c has been seen to change from 33.06 to 16.96 ohm^{-1}cm^2. At 303°K it is seen that in dilute solutions, the equivalent conductivity changes from 105.60 ohm^{-1}cm^2 to 68.64 ohm^{-1}cm^2 at moderate concentrated solution it decreases from 59.55 ohm^{-1}cm^2 to 44.02 ohm^{-1}cm^2 and at concentrated solution it decreased from 35.49 to 18.05 ohm^{-1}cm^2.

In general, it can be said that as concentration of lithium chloride is increased the equivalent conductivity decreases. However the relative decrease in equivalent conductivity seems to be larger at dilute solutions, it becomes smaller in moderately concentrated solutions and becomes still smaller in more concentrated solutions.

The equivalent conductivity Λ_c is plotted against the concentration of lithium chloride in different concentrations of urea added. (Fig. 4.1).

It can be seen that the plots are non-linear. Similar results have been observed at other temperatures also (293° and 308°K).

4.2 EFFECT OF UREA ON CONDUCTIVITY :

At given temperature (298°K) for given concentration of lithium chloride (0.1 M). The observed equivalent conductivity at different urea concentrations are as follows :

56.98 ohms^{-1}cm^{2} in 0% urea solution
62.37 ohms^{-1}cm^{2} in 5% urea solution
67.33 ohms^{-1}cm^{2} in 10% urea solution
70.47 ohms^{-1}cm^{2} in 15% urea solution
74.29 ohms^{-1}cm^{2} in 20% urea solution

At 293°K the equivalent conductivity is seen to increase from 56.98 ohm^{-1}cm^{2} to 74.29 ohm^{-1}cm^{2}. At 303°K the equivalent conductivity increased from 63.075 ohm^{-1}cm^{2} to 78.996 ohm^{-1}cm^{2}. At 308°K the equivalent conductivity increased from72.036 ohm^{-1}cm^{2} to 85.34 ohm^{-1}cm^{2}.

It can be seen, in general, that at a given concentration of LiCl, as urea concentration is increased the equivalent conductivity also increases.

Similar results were obtained for other concentrations i.e. from 0.008 M to 2 M lithium chloride.

The plots of equivalent conductivity Vs concentration of urea are given in Fig.4.7. The plots are not linear.

4.3 EFFECT OF TEMPERATURE ON CONDUCTIVITY :

The

The equivalent conductivity of 0.2 M Lithium chloride (definate concentration) in 5% urea + water mixture (fixed urea concentration) was studied at different temperatures. The results obtained were as follows :

At 293°K 0.2 M lithium chloride in 5% solution = 48.02 ohms^{-1}cm^{2}
At 298°K ,, ,, = 55.63 ,,
At 303°K ,, ,, = 59.55 ,,
At 308°K ,, ,, = 65.29 ,,

The equivalent conductivity thus is seen to increase from 48.02 ohms^{-1} cm^{2} to 65.29 ohm^{-1} cm^{2} as temperature is increased from 293 to 308°K ohms^{-1}cm^{2}.

for 10% urea solutionΛ_c increases from 54.20 ohm^{-1}cm^{2} to 67.07 ohm^{-1}cm^{2}

for 15% urea solution it increases from 57.28 ohm^{-1}cm^{2} to 70.42 ohm^{-1}cm^{2}

for 20% urea solution it increases from 59.16 ohm^{-1}cm^{2} to 74.38 ohm^{-1}cm^{2}

when temperature was changed from 293°K to 308 °K.

Similar results were obtained for other concentrations i.e. from 0.008 M to 2.0 M LiCl solution.

It can be seen that the equivalent conductivity increases as temperature increases. Plots of equivalent conductivity against temperature are given in Fig. 4.8and it is seen from figure, that the plots are non-linear.

4.4 APPLICATION OF DIFFERENT EQUATIONS :

The equivalent conductivity data given above have been examined in the light of the following equations :

1) Debye and Huckel equation
2) Walden equation or Walden product
3) Ion pair formation.

1) Debye Huckel equation :

Debye and Huckel worked out mathematically the magnitudes of asymmetric and electrophoretic effect in terms of such factors as valency of the ion, ionic concentratioin and dielectric constant and viscosity of the medium. For uni-univalent electrolytes, such as LiCl, which furnish two univalent ions, the following equation was derived :

$$\Lambda_c = \Lambda_o - \left[\frac{82.4}{(DT)^{\frac{1}{2}}\eta} + \frac{8.20 \times 10^5}{(DT)^{3/2}} \Lambda_o \right] \sqrt{c}$$

where D and η are dielectric constant and coefficient of viscosity of the medium respectively at a absolute temperature T, and C is concentration of the solution in moles per litre.

The first term in the bracket gives measure of the electrophoretic effect while the second term gives a measure of the asymmetry effect.

For a given solvent and at a given temperature, the above equation may be expressed as :

$$\Lambda_c = \Lambda_o - (A + B\Lambda_o)\sqrt{C}$$

Where A and B are constants.

The value of A and B for water at 25° comes out to be 60.2 and 0.229 respectively.

To test the validity of Debye Huckel equation, is first to see if a straight line is obtained by the plot of equivalent conductivity (Λ_c) against $\sqrt{C}$ and slope is calculated which gives the value of $(A + B\Lambda_o)$. The intercept will be Λ_o. The satisfactory agreement between calculated value of slope and that obtained by graphical method is a further test of Debye Huckel equation. Now in the present communication, we have analyzed the data in the light of the above equation. The experimental data is recorded in Tables 4.1–4.5 and the plots of equivalent conductivity Λ_c vs $\sqrt{C}$ are shown in Figs. 4.1-4.4

It is seen from the figure; that at dilute solution (from 0.008 M to 0.1 M) the equivalent conductivity varies linearly with concentration i.e. the plot is a straight line while at moderate concentration (0.02 to 5.0 M) deviation are seen and the graph is non-linear. At concentration solution the graph is nearly parallel to concentration axis showing little change in equivalent conductivity with increase in concentration of lithium chloride. It indicates thereby that the Debye Huckel equation is adequate for dilute solutions only.

This equation has been checked in case of a number of uni-kunivalent electrolytes and found to be true upto concentration of order of 0.02 N. At higher concentrations, slight deviations are noticed which increase with further increase in concentration. These deviations are attributed to certain approximations assumed in the derivation of the equation which are not valid when concentration is high.

If a solution is at infinit dilution i.e. if C is almost zero then the second term on the right hand side of the equation becomes negligible and Λ_c approaches Λ_o as expected.

2) Walden Product :

Walden[114,115] studied the conductance of tetra-ethyl ammonium picrate and proposed that the product of limiting conductance and the solvent viscosity should be constant for all temperature and solvents for a given electrolyte.

$$\Lambda_o \eta_o = \text{constant}$$

This rule is fairly reliable for large organic ions in various single solvents. The product $\Lambda_o \eta_o$ for tetra-ethyl ammonium ion was found to be 0.294 ± 0.001 for water, methanol, acetone as solvents at 25°C.

Fouss[116] has shown that the rule is less exact for mixtures of polar and non-polar solvents. The electrolyte, tetra butyl ammonium tetraphenyl boride, in spite of large size of its ions, shows a variation of the Walden product from 0.411 in pure acetonitrile to 0.386 in mixtures of 5% acetonitrile with 95% carbon tetra chloride, and the Walden product for tetra-methyl ammonium picrate in methanol-water mixtures rises from 0.57 in water to 0.67 in 60% methanol.

For small ions, the Walden product may show variations of two or three fold in different solvents. In many cases the mobilities in water are anomolously high compared with other solvents e.g. for potassium and sodium ions the Walden products in water are about twice the value in methanol.

P.B.Das[16] studied the conductivity of chlorides bromides, nitrates, bromates, iodates and sulphates of potassium and sodium. The ions appeared to interact and the ion-solvent interaction or structure breeking effect of the anion changes with change in dioxan content. According to him, less the value of $\Lambda_o \eta_a$ (Walden product), greater is the electrostatic ion-solvent interaction. The electrostatic charged density of the ion plays an important role in ion-solvent interaction and solvation. It appears that during migration, these common ions are covered with a sheath of solvent molecules which results in large size of the solvodynamic unit and hence a decrease in $\Lambda_o \eta_o$.

In the present communication, we report the $\Lambda_o \eta_o$ (Walden product) of Lithium chloride at different temperatures as 293°K, 298°K, 303°K and 308°K and different urea water compositions as 0%, 5%, 10% and 20% W/W. The results are shown in table 4.8 . At 293°K

Walden product increases from 1.2460 to 1.2644 $ohm^{-1} cm^{2}$ $equiv^{-1}$ poise when urea concentration changed from 0% to 20%. At 298°K, the change is from 1.2526 to 1.270 while at 303°K, it increases from 1.2624 to 1.2758 and finally at 308°K, it changes from 1.2631 to 1.2814. $ohm^{-1} cm^{-2}$ $equiv^{-1}$ poise.

It can be seen that as urea content is increased the Walden product is increased since urea is basic in nature automatically water acts as an acid and the three dimensional water structure is broken down, due to this viscosity decreases and the ionic mobility increases As a result the Walden product increases.

Effect of Temperature on Walden Product :

R.L.Blokhra and M.L.Parmar[79] studied the effect of temperature on Walden product. They measured equivalent conductivity, molar conductivity of different salts in dimethyl sulphoxide. The Walden product were calculated at different temperatures. They suggest in DMSO anions, especially halides, do not interact with solvent molecules. The negative temperature coefficient of the Walden product for ammonium bromide indicates that ammonium bromide acts as a structure breaker and this was confirmed with viscosity data.

Blokhra and Sengal[83] studied conductance measurements on tetraethyl ammonium halides in ethyleneglycol at different temperatures. The temperature dependence of Walden product of the salts in ethyleneglycol is discussed in terms of structure brecking/making characteristics of the salt. In case of large Walden products, their negative temperature coefficient have been attributed to a decrease in the structure of solvent.

It has been seen that in 0% urea the Walden product increases from 1.2460 to 1.2631 $ohm^{-1}cm^{2}$ $equi^{-1}$ poise when temperature was changed from 293°K to 308°K. For the same temperature range in 5% urea the Walden product increased from 1.2511 to 1.2654 $ohm^{-1}cm^{2}$ $equi^{1}$ poise.

In 10% urea the change observed was from 1.2533 to 1.2713 ohm^{-1} $cm^{2}equi^{-1}$ poise.

In 15% urea it increased from 1.2622 to 1.2761 $oh^{-1}cm^{2}equi^{-1}$ poise, and finally,

in 20% urea it increased from 1.2644 to 1.2814 $ohm^{-1}cm^{2}equi^{-1}$ poise, when temperature changed from 293°K to 308°K.

It can be seen as temperature is increased the Walden product also increases. The temperature coefficient is positive hence the lithium ion is a structure maker.

3) Ion fair formation :

Kraus and Foss[117] studied the conductance measurement of tetra isoamyl ammonium nitrate in Dioxane. The psssibility of formation of triple ion in solution and ion-pair formation was indicated and supported from the plots of $\Lambda\sqrt{c}$ versus C and log Λ_c against log c

According to these authors, the limiting conductance function, at low ion concentration for ion pair formation is given as

$$\Lambda = AC^{-\frac{1}{2}} + BC^{\frac{1}{2}}$$

Where A and B are constants.

In order to compare with experiment, it is convenient to multiply through by $\sqrt{C}$, giving

$$\Lambda\sqrt{C} = A + BC$$

This is a linear relationship between $\Lambda\sqrt{C}$ and concentration. The constants A and B can be determined by the intercept and slope of the plot.

These authors also studied the conductance of iodic acid in water for ion pair formation they have suggested an euqation[118]

$$C\Lambda^2 = K\Lambda^2_o$$

Where Λ = eq. cond at conc. C and Λ_o = Eq. conductivity at indifinite dilution, K = equilibrium constant.

We except therefore, that log Λ_c plotted against log C would be a straight line with slope = $-\frac{1}{2}$, when K is small.

Syal and Gurdev Kaur[92] studied the conductance measurements of some mineral acids, nitrogenous amines and electrolytes in monobromoacetic acid and its mixtures with nitrobenzene at 50°C. Triple ion formatioin is indicated by plots of log Λ_c against log C and found that there is an extensive ion pair formation in solution, which is further supported by results from plots of log Λ_c against log C. However, the existance of triple ion in mixture solvent was ruled out. The equivalent conductance for various bases (amine) first increases, reaches maxima and then decreases to have a constant value indicating the absence of triple ion formation. The absence of ion-pair formation in mixture solvent can be accounted to the increase in dielectric constant of mixture solvent. This also explains the over all higher values of equivalent conductance of amine in mixture solvent than in pure solvent.

Similar case is with the salts like NaCl, KCl and KI. There is no indication of formation of triple ions. In the present communication, we report the graph of $\Lambda_c\sqrt{C}$ Vs C for lithium chloride at 298° . It can be seen from the graph that at lower concentration (0.008 to 0.2 M) the graph is more or less straight line, at moderate concentration deviations are seen and more concentrated solutions the deviation is more pronounced for dilute solutions.

The product $\Lambda\sqrt{C}$ first increases linearly and at high concentration the increase is small and more or less remains constant. This clearly indicates that there is no ion pair formation in case of LiCl-urea water system.

In support to this, we report a plot of log Λ_c against log C for lithium chloride at 298°K (Fig. 4.5)

The graph shows at high concentration range log Λ changes little with C. At moderate concentration log Λ_c increase and at low concentration region, log Λ_c increases rapidly since the graph is non-linear the possibility of formation of ion pair is ruled out.

TABLE 4.1

Conductivity data for Lithium chloride in 0% urea-water solution at different temperatures

Equivalent conductivity $ohm^{-1} cm^{2}\ equiv^{-1}$

Concentration moles/litre	Temperature			
	293°K	298°K	303°K	308°K
0.008	81.45	89.05	98.74	101.14
0.02	75.73	83.52	87.17	88.74
0.04	60.03	65.25	74.16	80.12
0.06	59.01	62.06	71.05	76.97
0.08	54.91	60.03	66.99	74.03
0.10	53.94	56.98	63.07	70.03
0.20	45.02	49.02	55.98	68.47
0.30	40.02	42.92	50.02	54.32
0.40	38.06	40.02	45.02	46.00
0.50	35.00	35.14	41.06	44.00
0.75	29.00	30.97	33.06	34.10
1.00	25.05	26.00	25.05	29.05
1.50	19.89	20.64	21.28	22.09
2.00	16.05	16.53	16.92	17.40

TABLE 4.2

Conductivity data for Lithium chloride in 5 % urea-water solution at different temperatures

Equivalent conductivity ohm^{-1}cm^{2} equiv^{-1}

Concentration moles/litre	Temperature			
	293°K	298°K	303°K	308°K
0.008	89.50	99.50	105.60	109.28
0.02	79.17	86.47	92.65	95.48
0.04	68.67	73.95	76.04	85.69
0.06	63.22	68.44	73.37	78.44
0.08	60.13	65.79	70.14	75.58
0.10	58.02	62.37	68.64	73.70
0.20	48.02	55.63	59.55	65.29
0.30	43.00	46.45	53.12	56.84
0.40	41.49	42.15	47.63	50.02
0.50	38.10	38.97	44.02	45.41
0.75	31.43	33.06	35.49	36.42
1.00	26.66	27.05	29.75	30.79
1.50	20.35	20.99	22.50	23.31
2.00	16.35	16.96	18.05	19.00

TABLE 4.3

Conductivity data for Lithium chloride in 10 % urea-water solution at different temperatures

Equivalent conductivity ohm^{-1}cm^{2} equiv^{-1}

Concentration moles/litre	Temperature			
	293°K	298°K	303°K	308°K
0.008	96.10	106.15	108.20	115.90
0.02	83.08	92.04	96.83	97.44
0.04	70.68	78.30	82.65	89.17
0.06	65.25	71.34	75.40	84.75
0.08	64.05	70.47	73.95	78.30
0.10	63.42	67.33	71.94	74.99
0.20	54.20	58.46	62.29	67.07
0.30	48.74	51.91	55.53	58.58
0.40	44.15	46.98	49.80	52.20
0.50	41.23	43.50	45.41	47.32
0.75	34.45	35.61	37.00	38.04
1.00	29.71	30.18	30.97	31.58
1.50	23.02	23.50	24.36	24.58
2.00	18.79	19.27	19.66	19.96

TABLE 4.4

Conductivity data for Lithium chloride in 15 % urea-water solution
at different temperatures

Equivalent conductivity ohm^{-1}cm^{2} equiv^{-1}

Concentration moles/litre	Temperature			
	293°K	298°K	303°K	308°K
0.008	100.41	112.02	116.02	124.41
0.02	90.20	98.20	105.87	107.49
0.04	74.81	82.65	86.13	94.20
0.06	70.05	74.24	80.91	88.05
0.08	68.47	71.55	78.30	84.93
0.10	66.03	70.47	76.82	82.12
0.20	57.28	62.24	67.64	70.42
0.30	52.49	53.65	58.58	63.22
0.40	48.03	50.24	56.55	60.46
0.50	45.93	47.32	48.72	56.37
0.75	40.71	42.09	45.82	47.90
1.00	36.54	38.28	39.28	42.10
1.50	30.39	31.20	32.36	34.64
2.00	24.57	26.44	27.14	29.10

TABLE 4.5

Conductivity data for Lithium chloride in 20 % urea-water solution at different temperatures

Equivalent conductivity $ohm^{-1}cm^{2}$ $equiv^{-1}$

Concentration moles/litre	Temperature			
	293°K	298°K	303°K	308°K
0.008	116.00	118.11	124.64	130.08
0.02	93.52	106.79	111.34	115.62
0.04	81.99	88.01	93.74	101.13
0.06	75.95	80.04	86.97	89.90
0.08	71.01	76.01	81.99	85.94
0.10	67.42	74.29	78.99	85.34
0.20	59.16	64.38	69.16	74.38
0.30	52.78	57.13	60.03	65.80
0.40	50.02	54.15	57.20	61.77
0.50	48.54	49.06	53.41	57.59
0.75	40.48	42.80	45.70	49.64
1.00	37.14	38.80	41.49	44.89
1.50	30.68	32.71	35.14	38.10
2.00	25.01	28.40	30.40	32.84

TABLE 4.6

Conductivity data of Lithium chloride in 5% urea-water composition at 298° K

Frequency 200 Hz

Sr. No.	Concentration C Mols/lit.	$\sqrt{C}$	log C	Observed conductivity $\times 10^{-3}$ ohm^{-1}	Specific Conductivity $\times 10^{-4}$ ohm^{-1} cm^{-1}	Equivalent Conductivity ohm^{-1} cm^{2} equi.$^{-1}$	log Λ_c	$\Lambda\sqrt{C}$
1	0.008	0.0894	-2.096	0.914	0.7951	99.50	1.997	8.899
2	0.02	0.1414	-1.698	1.988	17.29	86.47	1.936	12.229
3	0.04	0.2000	-1.397	3.400	29.51	73.95	1.868	14.790
4	0.06	0.2449	-1.221	4.720	41.01	68.44	1.835	16.760
5	0.08	0.2828	-1.096	6.050	52.62	65.79	1.818	18.601
6	0.10	0.3162	-1.000	7.170	62.37	62.37	1.795	19.721
7	0.20	0.4472	-0.6989	12.79	117.21	55.63	1.744	24.882
8	0.30	0.5477	-0.5228	16.02	139.32	46.45	1.667	25.440
9	0.40	0.6324	-0.3979	99.38	168.61	42.15	1.624	26.651
10	0.50	0.7071	-0.3010	22.40	194.80	38.97	1.590	27.561
11	0.75	0.8600	-0.1249	28.50	247.91	33.06	1.519	28.632
12	1.00	1.000	0.000	31.10	263.62	27.05	1.432	27.057
13	1.50	1.2247	0.1760	36.21	314.94	20.99	1.332	25.714
14	2.0	1.4142	0.3010	39.01	339.21	16.96	1.229	23.992

Table 4.7

Conductivity data of Lithium chloride in different urea-water compositions at 298°K

Concentration mole/lit	$\sqrt{C}$	log C	Equivalent conductivity $ohm^{-1}cm^{2}equiv^{-1}$	log Λ_c	$\Lambda\sqrt{c}$
			Wt. % of urea ir urea + H_2O = 0 %		
0.008	0.0894	-2.096	89.50	1.951	8.00
0.02	0.1414	-1.698	83.52	1.921	11.81
0.04	0.2000	-1.397	65.25	1.814	13.05
0.06	0.2449	-1.221	62.06	1.792	15.20
0.08	0.2828	-1.096	60.03	1.778	16.97
0.10	0.3162	-1.000	56.98	1.755	18.01
0.20	0.4472	-0.6989	49.02	1.690	21.92
0.30	0.5477	-0.5228	42.92	1.632	23.50
0.40	0.6324	-0.3979	40.02	1.602	25.37
0.50	0.7071	-0.3010	35.14	1.595	29.85
0.75	0.8600	-0.1249	30.97	1.490	26.82
1.00	1.0000	-0.0000	26.00	1.415	26.01
1.50	1.2247	0.1760	20.54	1.314	25.28
2.00	1.4142	0.3010	16.53	1.218	23.37
			Wt. % of urea in urea + H_2O = 5 %		
0.008	0.0894	-2.096	99.50	1.997	8.91
0.02	0.1414	-1.698	86.47	1.936	12.22
0.04	0.2000	-1.397	73.95	1.868	14.79
0.06	0.2449	-1.221	68.44	1.835	16.76
0.08	0.2828	-1.096	65.79	1.818	18.60
0.10	0.3162	-1.000	62.37	1.795	19.72
0.20	0.4472	-0.6989	55.63	1.744	24.88
0.30	0.5477	-0.5228	46.45	1.667	25.44
0.40	0.6324	-0.3979	42.15	1.624	26.65
0.50	0.7071	-0.3010	38.97	1.590	27.56
0.75	0.8600	-0.1249	33.06	1.519	28.63
1.00	1.0000	-0.0000	27.05	1.432	27.05
1.50	1.2247	0.1760	20.99	1.332	25.71
2.00	1.4142	0.3010	16.96	1.229	23.99

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Concentration mole/lit	$\sqrt{C}$	log C	Equivalent conductivity $ohm^{-1}cm^{2}equiv^{-1}$	$\log \Lambda_c$	$\Lambda\sqrt{c}$
Wt. % of urea in uread + H_2O = 10 %					
0.008	0.0894	-2.096	106.15	2.027	9.52
0.02	0.1414	-1.698	92.04	1.963	13.01
0.04	0.2000	-1.397	78.30	1.893	15.66
0.06	0.2449	-1.221	71.34	1.853	17.47
0.08	0.2828	-1.096	70.47	1.848	19.983
0.10	0.3162	-1.000	67.33	1.828	21.29
0.20	0.4472	-0.6989	58.46	1.766	26.14
0.30	0.5477	-0.5228	51.91	1.715	28.43
0.40	0.6324	-0.3979	46.98	1.671	29.71
0.50	0.7071	-0.3010	43.50	1.638	30.75
0.75	0.8600	-0.1249	35.61	1.551	30.84
1.00	1.0000	-0.0000	30.18	1.471	30.18
1.50	1.2247	0.1760	23.50	1.372	28.84
2.00	1.4142	0.3010	19.27	1.284	27.84
Wt. % of urea in urea + H_2O = 15 %					
0.008	0.0894	-2.096	112.02	2.049	10.01
0.02	0.1414	-1.698	98.20	1.992	13.88
0.04	0.2000	-1.397	82.65	1.917	16.53
0.06	0.2449	-1.221	74.24	1.870	18.18
0.08	0.2828	-1.096	71.55	1.854	20.23
0.10	0.3162	-1.000	70.47	1.848	22.28
0.20	0.4472	-0.6989	62.24	1.794	27.83
0.30	0.5477	-0.5228	53.65	1.729	29.38
0.40	0.6324	-0.3979	50.24	1.701	31.77
0.50	0.7071	-0.3010	47.32	1.675	33.46
0.75	0.8600	-0.1249	39.09	1.592	33.85
1.00	1.0000	-0.0000	38.28	1.582	38.26
1.50	1.2247	0.1760	31.20	1.4942	38.21
2.00	1.4142	0.3010	26.44	1.4224	37.39

....

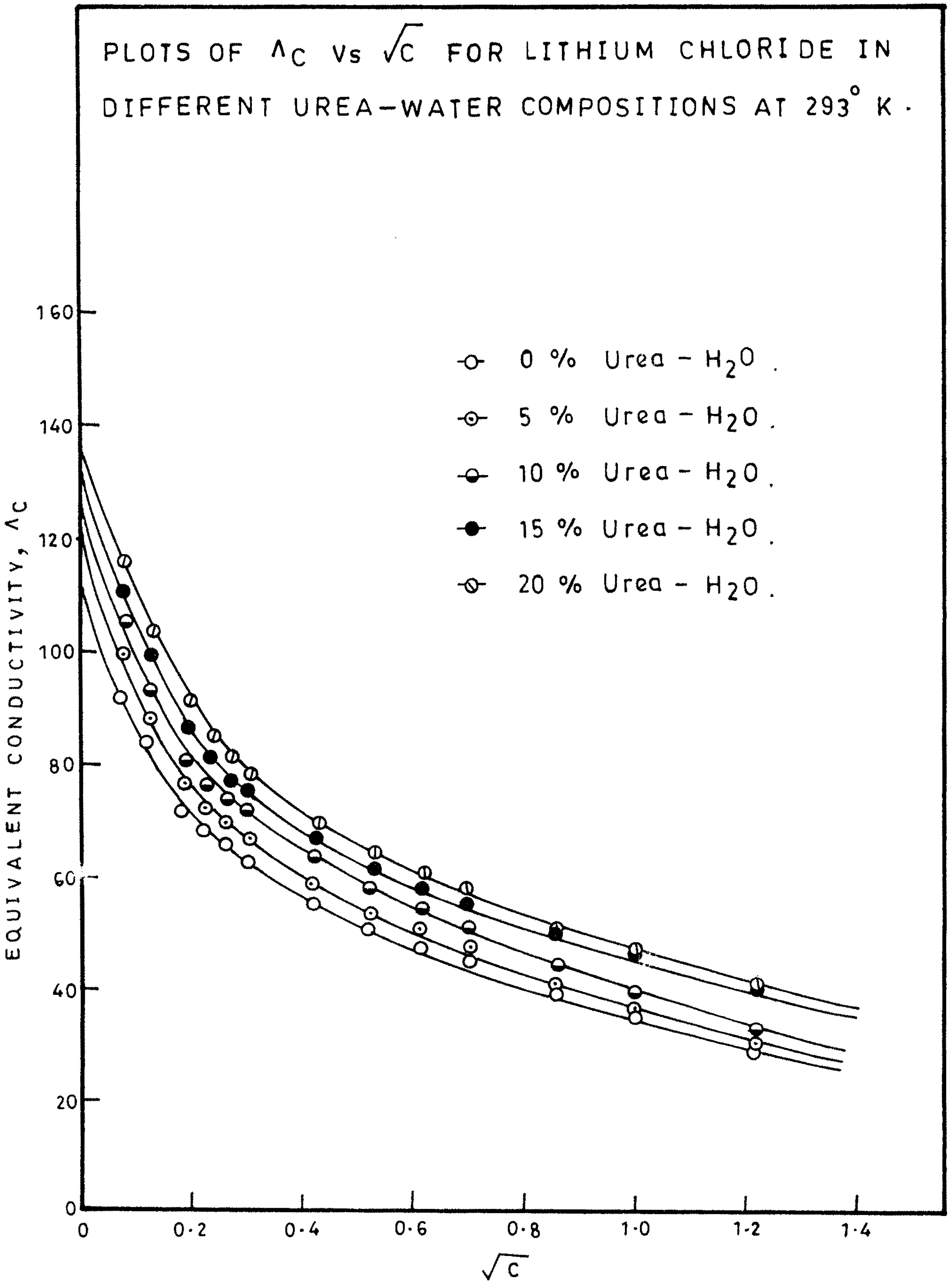
Concentration mole/lit	$\sqrt{C}$	log C	Equivalent conductivity $ohm^{-1} cm^{2} equiv^{-1}$	$\log \Lambda_c$	$\Lambda \sqrt{c}$
Wt. % of urea in urea + H_2O = 20 %					
0.008	0.0894	-2.096	118.11	2.072	10.56
0.02	0.1414	-1.698	106.79	2.028	15.10
0.04	0.2000	-1.397	88.01	1.944	17.60
0.06	0.2449	-1.221	80.04	1.903	19.60
0.08	0.2828	-1.096	76.00	1.880	21.50
0.10	0.3162	-1.000	74.29	1.870	23.49
0.20	0.4472	-0.6989	64.39	1.808	28.79
0.30	0.5477	-0.5228	57.13	1.756	31.29
0.40	0.6324	-0.3979	54.15	1.733	34.25
0.50	0.7071	-0.3010	49.46	1.690	34.69
0.75	0.8600	-0.1249	42.80	1.631	37.06
1.00	1.0000	-0.0000	38.80	1.588	38.80
1.50	1.2247	0.1760	32.71	1.515	40.06
2.00	1.4142	0.3010	28.40	1.453	40.17

TABLE 4.8

$\Lambda_o \eta_o$ (Walden product) of Lithium chloride in different urea-water composition at different temperature

$\Lambda_o \eta_o$ (ohm^{-1}cm^2 equiv^{-1} poise)

Mass fraction of urea	Temperature (°K)			
	293	298	303	308
0 %	1.2460	1.2526	1.2624	1.2631
5 %	1.2511	1.2530	1.2630	1.2654
10 %	1.2533	1.2616	1.2646	1.2713
15 %	1.2622	1.2655	1.2739	1.2761
20 %	1.2644	1.2709	1.2758	1.2814



PLOTS OF Λ_C Vs $\sqrt{C}$ FOR LITHIUM CHLORIDE IN DIFFERENT UREA–WATER COMPOSITIONS AT 293° K.

FIG. NO. 4·1

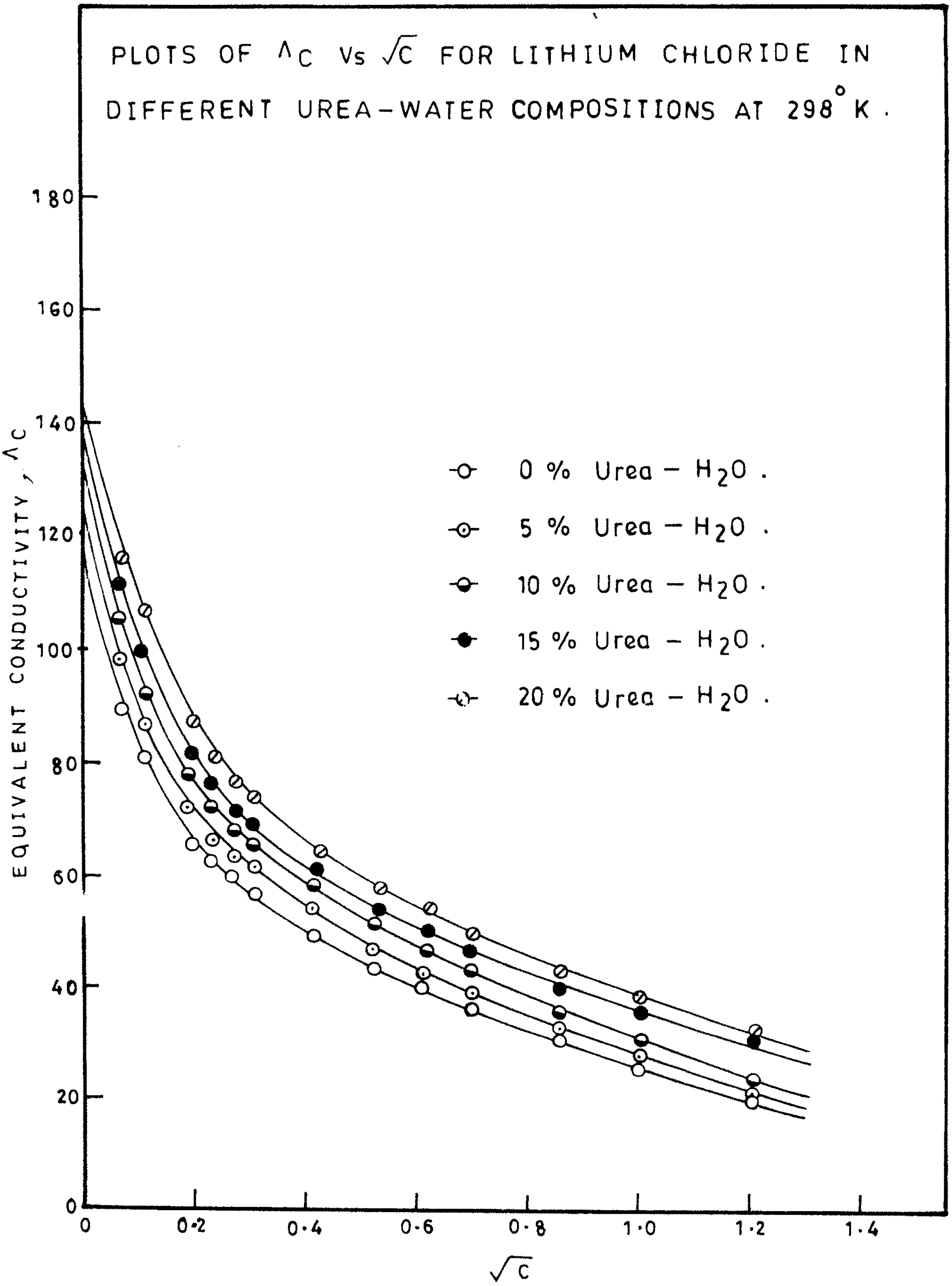
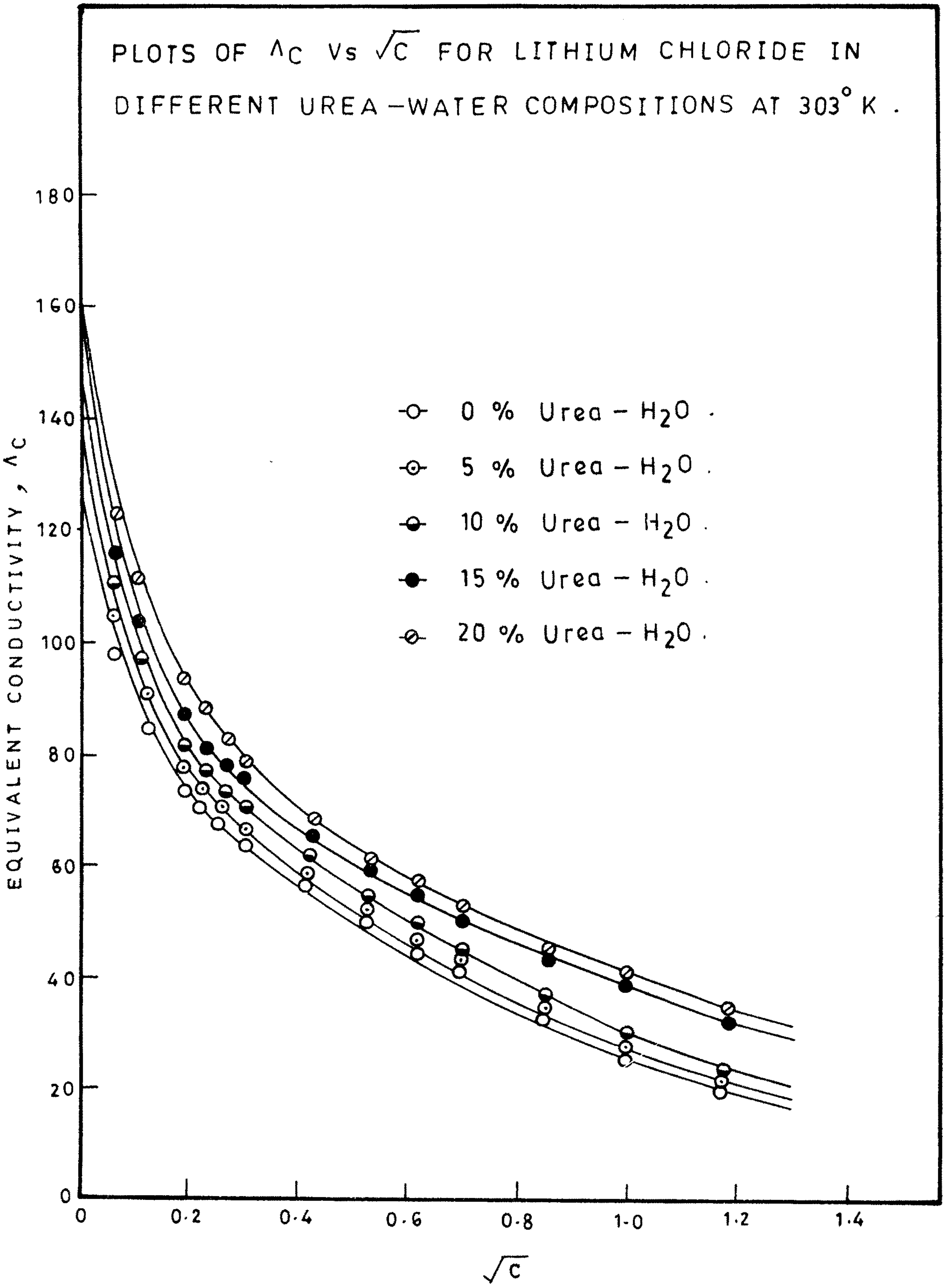

PLOTS OF Λ_C Vs $\sqrt{C}$ FOR LITHIUM CHLORIDE IN DIFFERENT UREA-WATER COMPOSITIONS AT 298° K.

FIG. NO. 4·2



PLOTS OF Λ_C Vs $\sqrt{C}$ FOR LITHIUM CHLORIDE IN DIFFERENT UREA-WATER COMPOSITIONS AT 303° K.

FIG. NO. 4·3

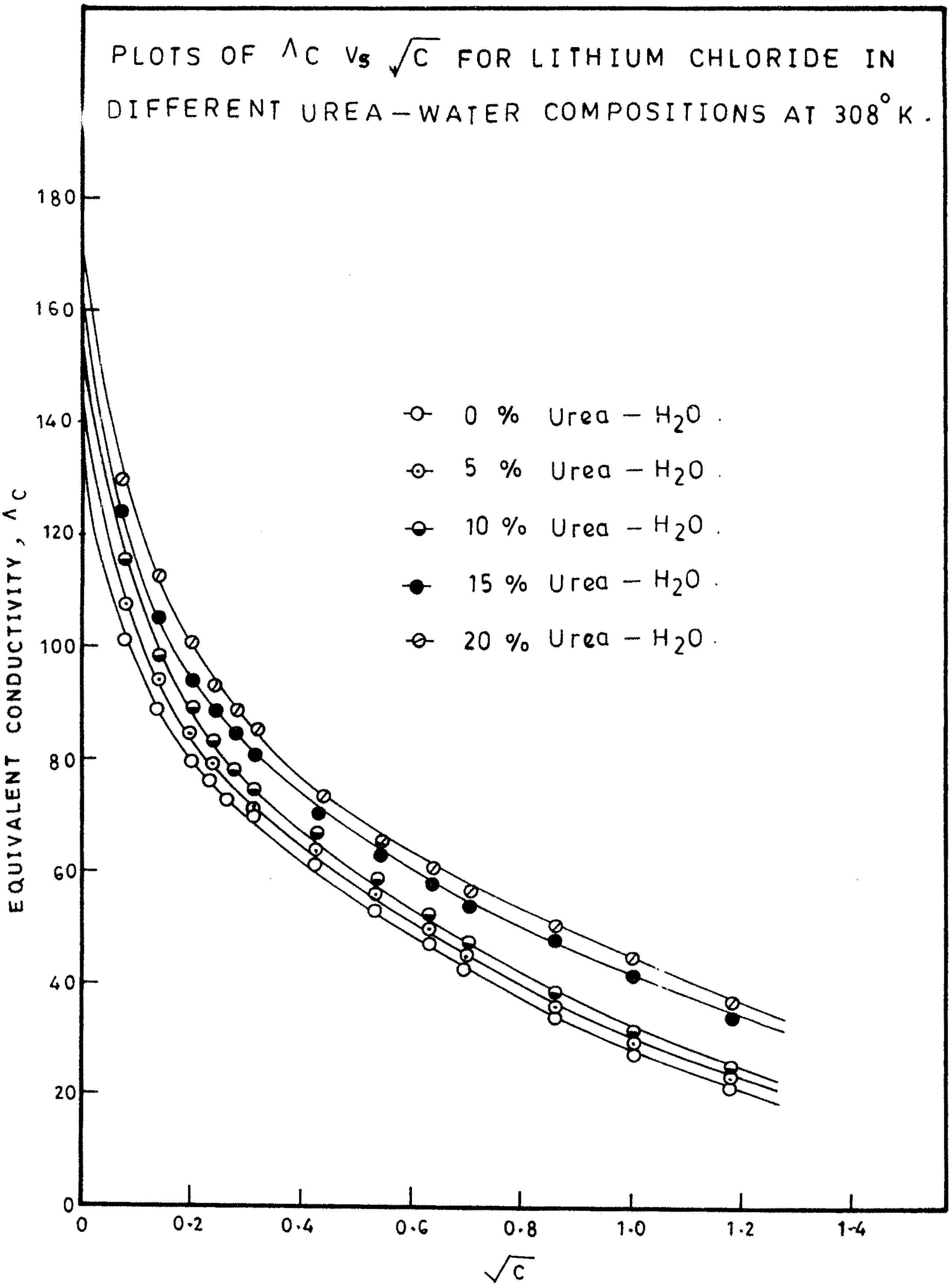

PLOTS OF Λ_C Vs $\sqrt{C}$ FOR LITHIUM CHLORIDE IN DIFFERENT UREA – WATER COMPOSITIONS AT 308°K.
0 % Urea – H_2O.
5 % Urea – H_2O.
10 % Urea – H_2O.
15 % Urea – H_2O.
20 % Urea – H_2O.
EQUIVALENT CONDUCTIVITY, Λ_C
0
20
40
60
80
100
120
140
160
180
0
0·2
0·4
0·6
0·8
1·0
1·2
1·4
$\sqrt{C}$

FIG. NO. 4·4

PLOTS OF Log Λ_C Vs Log C FOR LITHIUM CHLORIDE IN DIFFERENT UREA–WATER COMPOSITIONS AT 298° K.

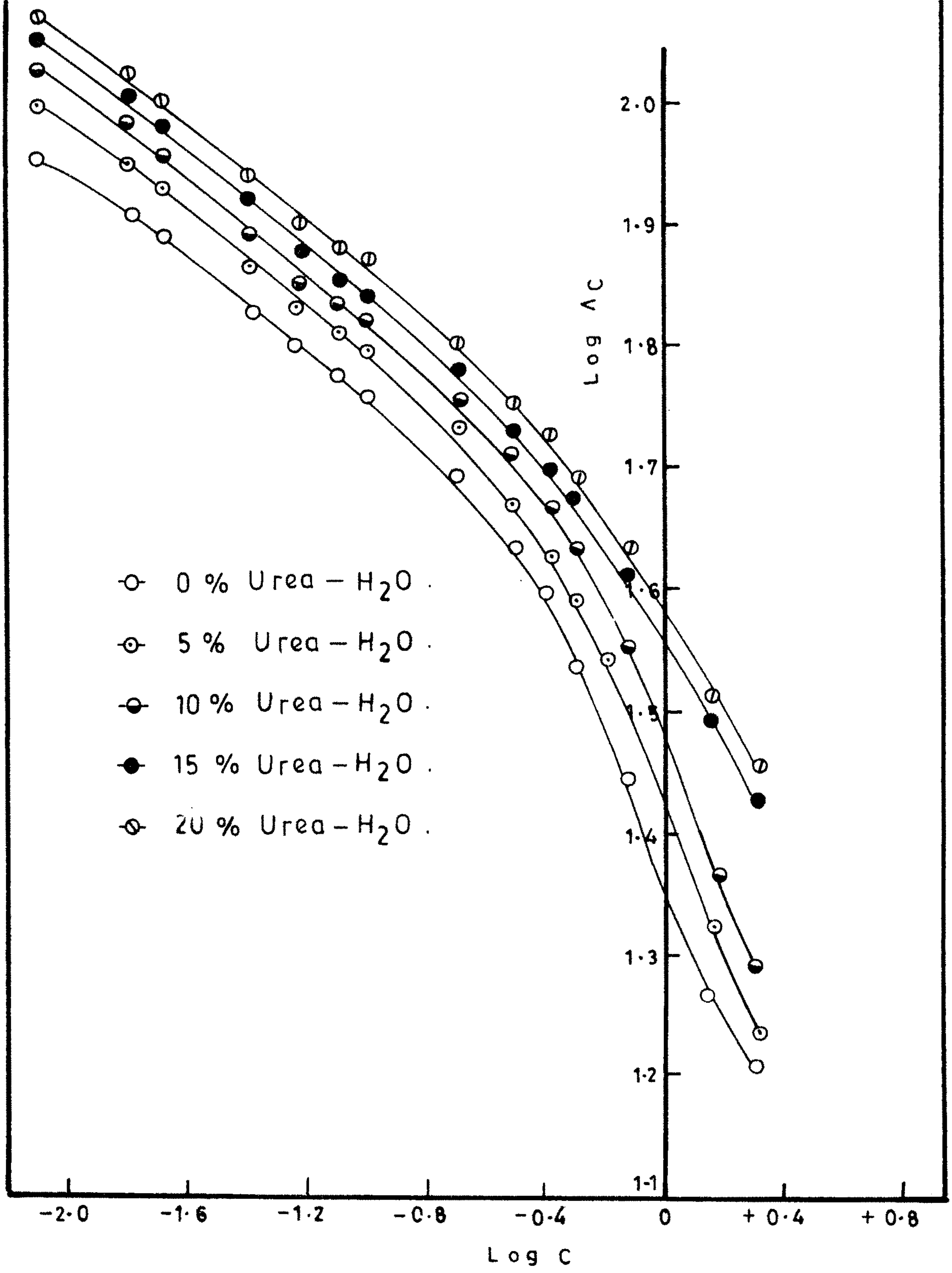
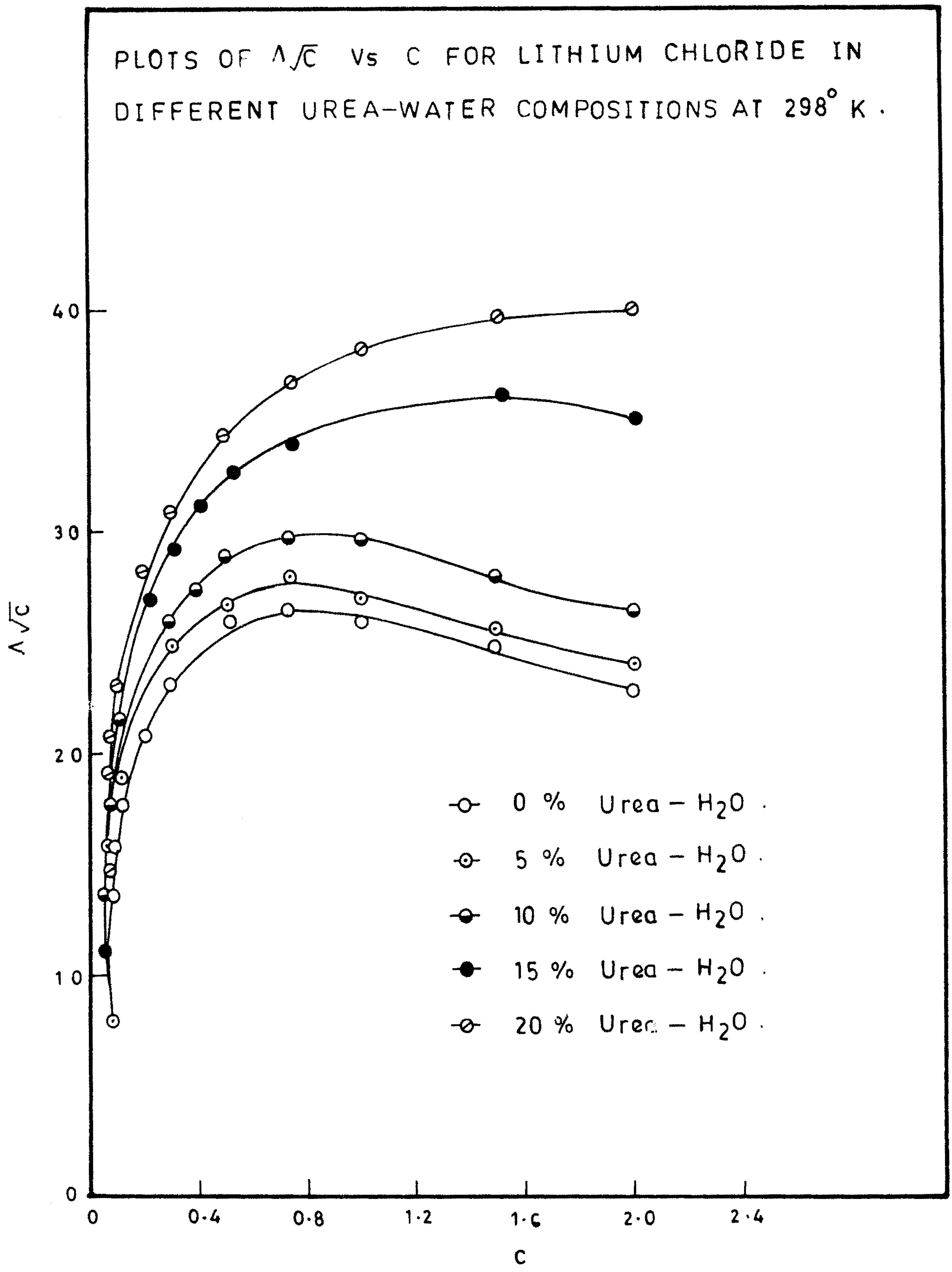
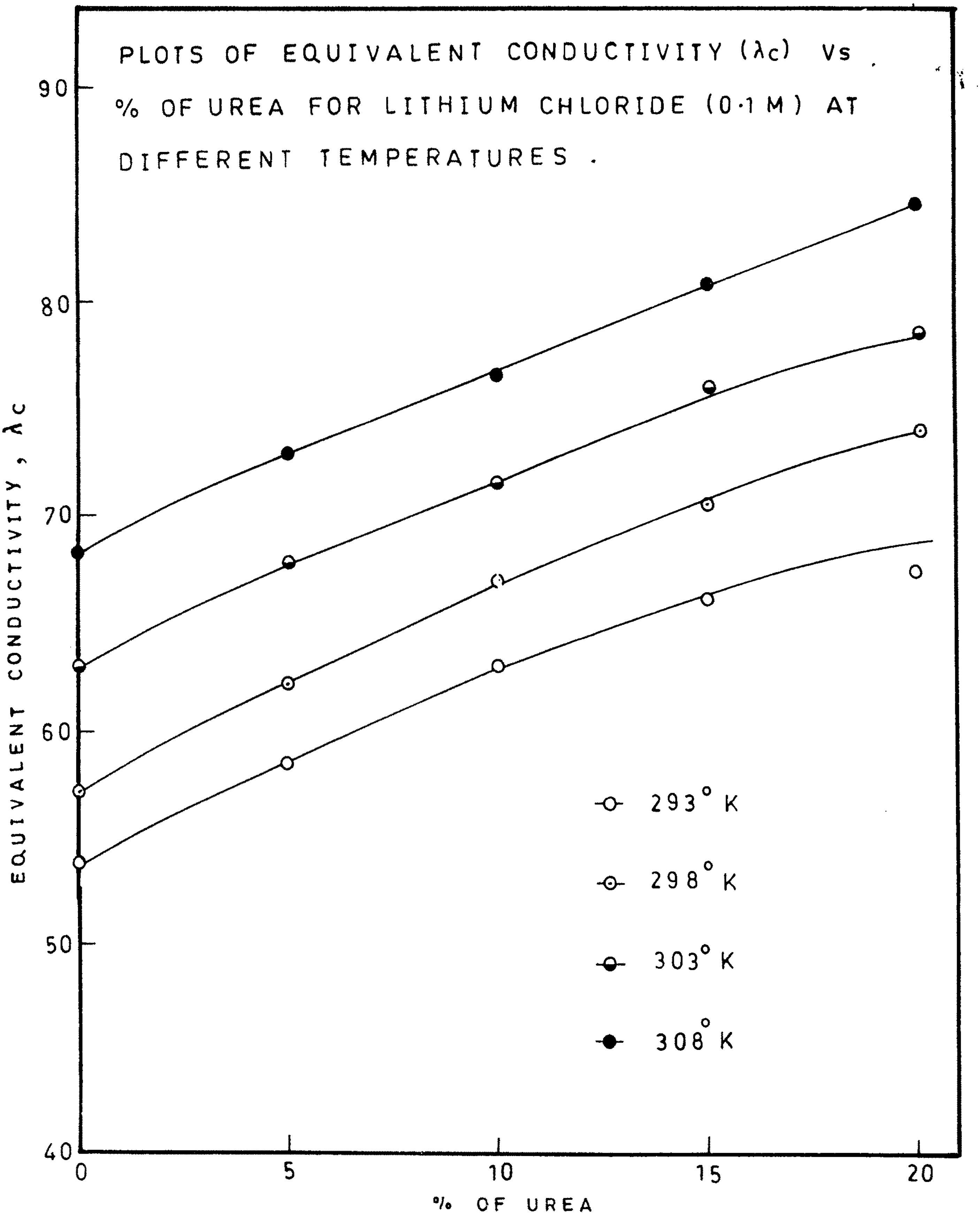


FIG. 4·5



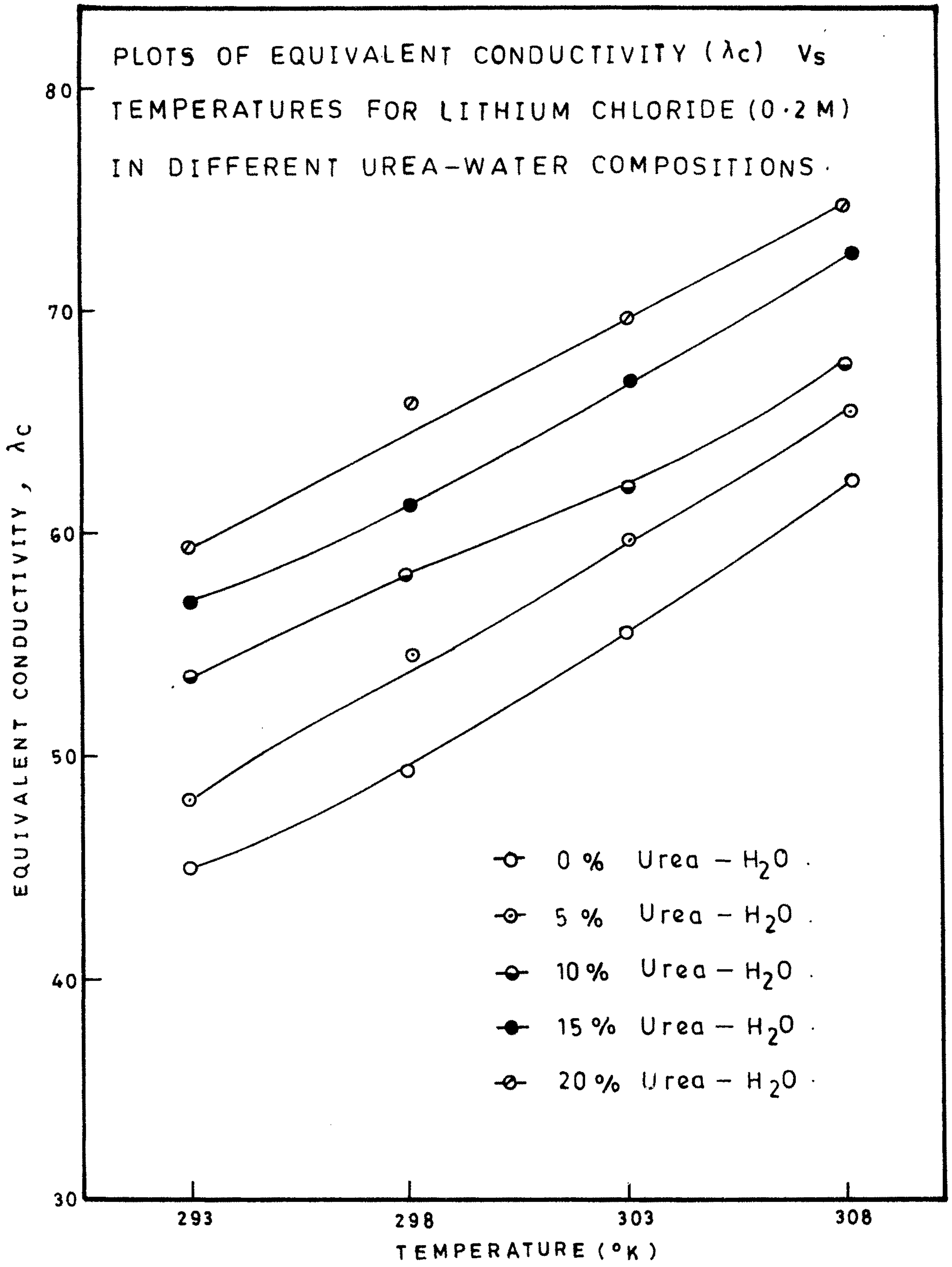
PLOTS OF $\Lambda\sqrt{C}$ Vs C FOR LITHIUM CHLORIDE IN DIFFERENT UREA-WATER COMPOSITIONS AT 298° K.

FIG. NO. 4·6



PLOTS OF EQUIVALENT CONDUCTIVITY (λc) Vs % OF UREA FOR LITHIUM CHLORIDE (0·1 M) AT DIFFERENT TEMPERATURES.

FIG. NO. 4·7



PLOTS OF EQUIVALENT CONDUCTIVITY (λ_c) Vs TEMPERATURES FOR LITHIUM CHLORIDE (0·2 M) IN DIFFERENT UREA-WATER COMPOSITIONS.

FIG. NO. 4·8