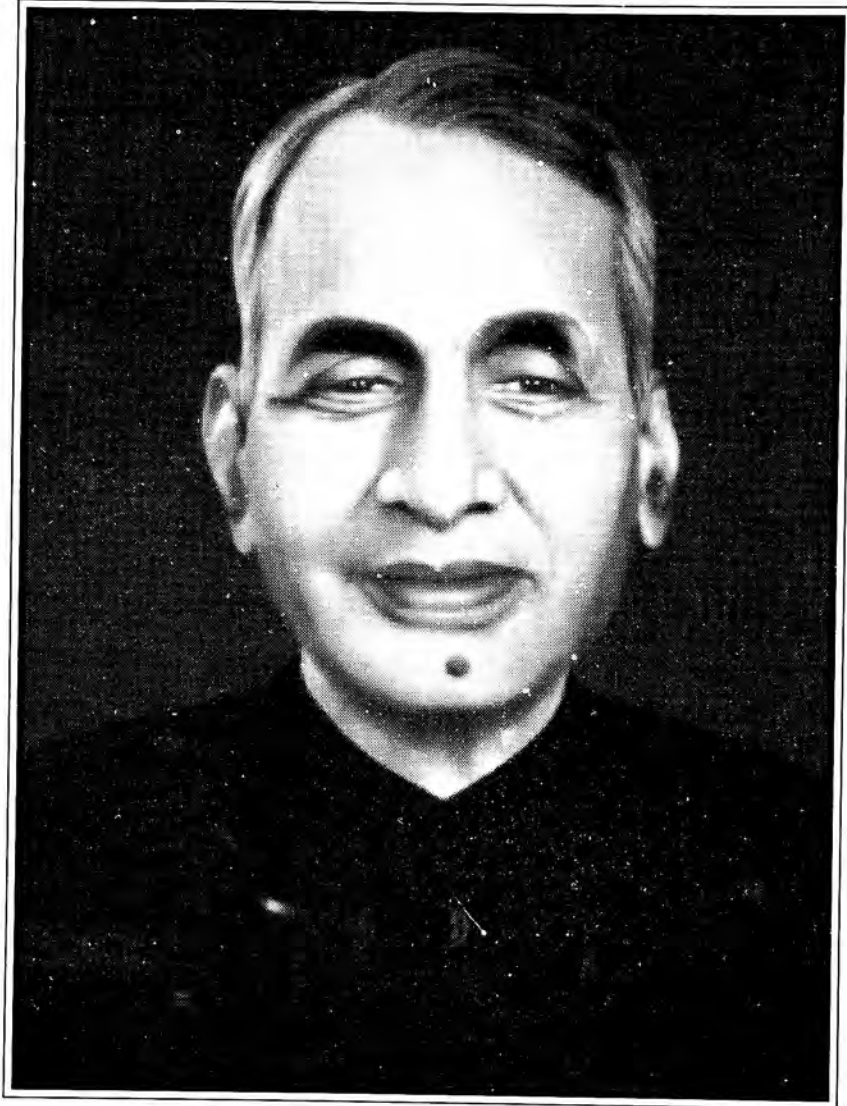


BALBHADRA PRASAD
(26 November 1905 - 12 March 1987)

Biog. Mem. Fell. INSA, New Delhi **34** 51-63 (2008)





Shri. S. S. S.



BALBHADRA PRASAD

(1906-1987)

(Elected Fellow 1958)

FAMILY BACKGROUND AND EARLY EDUCATION

BALBHADRA PRASAD passed away on 12th March 1987 after a brief illness in Bhubaneswar, where he was staying with his son Sri SK Prasad. In his sad demise, the country lost a great scientist, an administrator, a philanthropist and a man of rare integrity.

Balbhadra Prasad was born on 26th November 1905 (school record 31.01.1905) in the village Uгна, PO Jagdishpur, Dist. Shahabad (now Bhojpur), Bihar. The village at that time had no post office. He was the second child of his parents. He had three sisters and one brother, who was younger to him. His father, Ram Prakash Lal was a small zamindar. His mother was a generous lady from whom he inherited an unbounded faith in humanistic values and generosity. His father was a brave and wise man. In Prof. Prasad's words, "One memory of my father's bravery, I can never forget in my life. In 1917, my district had a bad communal riot. A Hindu mob, over a thousand, came to our house and wanted my father to lead and loot the Muslims in my village and in neighbouring villages. My father refused in spite of threats from the mob. Our house could have been looted. In spite of this risk, he was firm and the looting in my village and neighbouring villages was avoided." His father could not meet the expenses of college education of both the sons. The younger one stopped his studies after B.Sc. He joined Bihar Agriculture Service and retired as a Class I Officer. A cousin was a lawyer and another, Professor of Economics in Bihar University.

In 1921, he was married to Saraswati Devi, daughter of Sri Ram Prasad, who too was a zamindar. In addition, he was employed in the High Court at Patna. Prof. Prasad's two brother-in-laws were medical doctors, one specializing in Paediatrics and the other in Pathology. Mrs. Prasad and Prof. Prasad brought up Banbihari Das a boy from Cuttack from his childhood as their son, who later worked in Telco. Their only son Sri Krishna Prasad, was in Indian Forest Service, who worked in Orissa during the entire tenure of service.

Prof. Prasad's early education was under a Moulavi for one year (1910-11). Then in 1911, he joined primary classes. After passing lower primary he studied one year at home and then joined Arrah Town school in 1917. When he was in first class, non-cooperation movement started. He got involved in the movement as a result he



passed the Matriculation in the 2nd Division. Then he discontinued studies for one year, taking part in the non-cooperation movement.

In 1922, he joined the I.Sc. Classes in Patna College. He stood first in the first year examination and won Wilson Prize. In 1924, he passed the I.Sc. Examination in the first division. He joined the B.Sc. Classes and passed the B.Sc. (Hons.) in the first class securing record works. He was awarded P.G. scholarship for studying M.Sc. in Chemistry. He joined the M.Sc. Classes. In 1927 he was awarded a State Scholarship. He joined the B.Sc. Classes of the University College of London University. In 1929 he passed the B.Sc. Examination of London University with first class honours in Chemistry.

PROFESSIONAL CAREER

In 1929 he joined Ravenshaw College as an Assistant Professor of Chemistry and subsequently Professor of Chemistry and served the department for over two decades. He started research work on viscosity of liquids and solutions of electrolytes and non-electrolytes. In 1943, he was awarded the D.Sc. degree of London University on the basis of the work done in Ravenshaw College. In 1937 two research scholars, AS Chakravarti and MK Srinivasan joined him. AS Chakravarti was the first person to take Ph.D. (Patna University) under his guidance and retired as Director, Sugarcane Research Institute, Pusa, Bihar. MK Srinivasan unfortunately died before he could submit his thesis.

In 1944, Utkal University was established. The PG department of Chemistry was opened in Ravenshaw College in 1947. It was Prof. Prasad, who planned the extension of the existing Chemistry Department so that PG section could be accommodated. In 1947, PG in Chemistry classes were started. A number of his undergraduate students who took their M.Sc. from other universities joined as lecturers. One of the new lecturers, Sukumar Aditya (the author of this memoir) worked under his guidance and was awarded Ph.D degree of the Utkal University in 1951. He retired as Prof. of Physical Chemistry Department of Applied Chemistry, Calcutta University. The same year, under Prof. Prasad's inspiration and guidance of Prof. SS Guhasircar, Prof. MK Rout was awarded Ph.D. degree of the Utkal University. Prof. Rout retired as VC of the Utkal University. The third Ph.D. under Prof. Prasad was PK Jena (retired as Director, RRL, Bhubaneswar). Sisir Coomar Sircar had his Ph.D. under his guidance and served the IIT, Kharagpur as Professor of Metallurgy. Of the number of students who did their M.Sc. thesis work under Professor Prasad, Bimbadhar Nayak and Rabindra Kumar Nanda were outstanding. They subsequently did their doctoral work. Both of them retired as Professors of Chemistry, the former from IIT, Kharagpur and the latter from Utkal University.



In 1952, Professor Prasad became DPI, Orissa and in 1957 he left Orissa to become the Vice Chancellor of Patna University. In October 1961, he became the Vice Chancellor of Allahabad University and retired in 1965.

Then he joined the Chemistry Laboratory of Science College, Patna University, Patna. From 1965 to 1972 he guided research work. CSIR and INSA provided research fellowship. A number of research workers earned their Ph.D's. under his guidance. They are Gangadhar Sahoo, Lakshmi Sharma, Hirendra Kumar Sinha, Bimal Kant Choudhary, Surya Narain Jha, Amar Chandra Jha, Suresh Chandra Lal, Ashok Kumar Jha and Chandrakant Choudhary. Dr. JC Ghosh Reader in Chemistry, joined him and worked in collaboration.

The first scientist who immensely influenced Professor Prasad's life was Professor KS Caldwell, Professor of Chemistry, Patna College. His accuracy in class demonstration experiments were superb. Prof. AS Khan, of the same college, influenced his life by his excellent teaching, integrity and impartiality. He was also influenced by Acharya PC Ray's ideals. In England Prof. FG Donnan created his deep interest in thermodynamics. Prof. Donnan's and Prof. Robinson's excellent teaching and interest in students impressed him much. He always adored the affection of Prof. NR Dhar of Allahabad and Prof. PB Ganguly of Patna University. Prof BC Guha and Prof. BN Ghosh were his life long friends; their friendship started while in the University of London.

SCIENTIFIC CONTRIBUTIONS

In early thirties, when Professor Prasad joined Ravenshaw College, the teaching in Chemistry there was upto B.Sc. (Pass) level. Nevertheless there was research activity/tradition in the department. Prof. BK Singh carried out research work in optical rotatory dispersion of camphor's with two assistants, Mr. HB Behera and Mr. I Mohanty.

There was no facilities to pursue any experimental research work in Physical Chemistry. So Professor Prasad started research work with the examination of viscosity data available in the Landolt - Bornstein's Tables. On examination of the viscosity of fused NaNO_3 , KNO_3 , PbCl_2 , PbBr_2 , and $\text{K}_2\text{Cr}_2\text{O}_7$, he concluded that Andrade - Shepherd's formula $\log \eta = \alpha + \beta/T$ held for unassociated liquids and for the associated liquids he suggested the equation $\log \eta = \alpha + \beta/(T-\theta)$. In a subsequent publication, he examined other equations of viscosity of liquids like Macleod's, Silverman's, Madge's etc. and showed that Andrade's simple equation $\log \eta = \alpha + \beta/T$ might be considered the best for unassociated liquids. He pointed out the drawbacks in the assumptions in Irany's viscosity equation. Using simple Andrade equation, on the basis that the mechanism of thermal conductance is the same as that of viscosity, he derived a simple expression for viscosity and thermal conductance of liquids and highly compressed gases, given by the equation, $K = C_p \eta$ where K is the

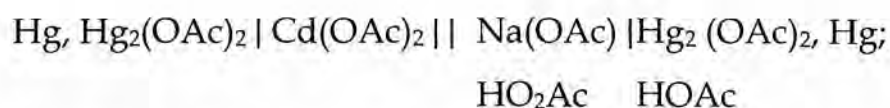
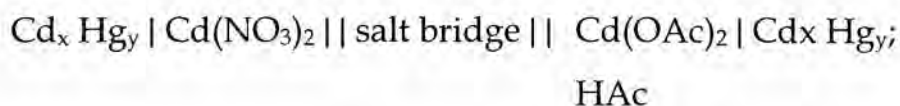


thermal conductance, C_p , sp. heat and η is the viscosity. These researches were published in *Phil Mag* and *Trans. Farad. Soc.* over the period 1930-1948.

In the meantime he worked hard to set-up a laboratory for doing experimental work on measurement of viscosity of solutions and apparent molal volume of solutes. For this purpose he set up precision thermostats and got viscometer and pycnometers fabricated for accurate work. Sri HB Behera who worked with Prof. BK Singh helped a lot in fabrication work. The present memoir writers who were Prof. Prasad's students, had the good fortune of meeting Mr Behera and share his experiences. In thirties and forties with large pycnometers (~60 ml) and viscometers (flow times greater than 30 min), stop watch with accuracy ± 0.2 sec, and temperature better than ± 0.01 he could get density, viscosity coefficient parameters upto 5th decimal place~quite a feat in those days. Viscosities of solutions of a number of weak electrolytes, mono-monovalent and bimonivalent salts were measured at 35° C. The Falkenhagen - Vernon equation was found to apply to them. Apparent molal volumes of simple electrolytes as well as mixtures of electrolytes in aqueous solution were determined and these followed Redlich-Rosenfeld equation $\phi = \phi_0 + K\sqrt{C}$.

Subsequently he shifted his research interest to the 'Behaviour of Electrolytes in aqueous solutions', when S Aditya, one of his old students joined Ravenshaw College as a lecturer and wanted to work for his Ph.D. in the incomplete dissociation of salts in solutions. The dissociation constants of a number of bi-univalent salts like $Pb(NO_3)_2$, $Cd(NO_3)_2$, $Pb(OAc)_2$, $Cd(OAc)_2$ etc. were determined. While studying these systems anion reversible electrodes, $Hg/Hg_2(OAc)_2$, OAc^- ; Ag/CNS , CNS^- electrodes were developed, as the anion sensitive electrode would be more sensitive in assessing the dissociation since, on dissociation, a bi-univalent salt would produce more anions on dissociation $Pb(OAc)_2$ would produce more acetate ions and as such acetate reversible electrode would be a better sensor.

In the study of dissociation of Cadmium acetate, cells,



And $Cd_x Hg_y | Cd(OAc)_2 | Hg_2(OAc)_2, Hg$ were used.



In the initial stage, salt bridge were used, as also the cells with no liquid junction. Extensive studies of potentials associated with salt bridge with different salts were reported.



Subsequent work in Patna in most of the studies no salt bridge was used. The standard potential and thermodynamic quantities for $\text{Hg}|\text{Hg}_2\text{SO}_4, \text{SO}_4^{2-}, \text{Hg}|\text{Hg}_2(\text{OAc})_2, (\text{OAc})^-$ and $\text{Ag}|\text{AgCNS}, \text{CNS}^-$ electrodes were reported. He critically examined Davies equation $\log \gamma_i = -AZ_i^2[\sqrt{\mu}/(1+\sqrt{\mu})]^{-0.2\mu}$ for the activity coefficient of ions and suggested modification of the equation as $\log \gamma_i = -AZ_i^2[\sqrt{\mu}/(1+\sqrt{\mu})] - \beta_i\mu$.

For HCl ; $\log \gamma_{\text{H}^+}\gamma_{\text{Cl}^-} = -2[\sqrt{\mu}/(1+\sqrt{\mu})] - (\beta_{\text{H}^+} + \beta_{\text{Cl}^-})\mu$.

$\beta_{\text{HCl}}(\beta_{\text{H}^+} + \beta_{\text{Cl}^-})$ was determined using suitable extrapolation. β for an electrolyte Mx was obtained as $\beta_{\text{Mx}} = \beta_{\text{My}} + \beta_{\text{Nx}} - \beta_{\text{Ny}}$. Using modified Davies equation he and his coworkers in Patna. Science College, Patna, determined the thermodynamic dissociation constants for a number of weak acids like, acetic acid, oxalic acid, succinic acid etc. without assuming a rough value by regression.

Thermodynamic parameters for a number of bi-univalent and bi-bi-valent salts have been reported. With combination of a number of concentration cells the thermodynamic properties of alums were reported.

AWARDS AND HONOURS

- Fellow of the Indian National Science Academy 1958.
- Fellow of the National Academy of Sciences, Allahabad 1962.
- President, Institute of Chemists (India) 1974-1975.
- Vice-President, Indian Chemical Society.
- Acharya PC Ray Memorial Medalist, 1967.
- Member, Board of Scientific and Industrial Research, Government of Orissa 1956-1957.
- Tribute to Dr. Balbhadra Prasad, the man and the Scientist by Patna Citizen's forum in his 75th year.

POSITIONS HELD

- Assistant Professor of Chemistry, Ravenshaw College, Cuttack, September 1929-February 1936.
- Professor of Chemistry, Ravenshaw College, February 1936-September 1952. Officiated as Principal for a few months during the period.
- Director of Public Instruction, Orissa September 1952-March 1957. President, Board of Secondary Education for most of the period.
- Dean of Faculty of Science, Utkal University 1946-1957. Member of Senate, Academic Council and Syndicate, Utkal University.
- Vice-Chancellor, Patna University, March 1957 - July 1960. Chairman, Bihar School Examination Board for two years during the period.
- Vice-Chancellor, Allahabad University, October 1961 - March 1965.
- Emeritus Scientist of the CSIR, April 1965 - March 1970.



- Chemical Adviser to Govt. of Orissa, during World War II.
- Air-raid Warden, World War II.
- Professor in Charge of games and sports in Ravenshaw College.
- Member of Orissa Athletic Association; also was Vice-President for several years.
- Professor in-charge of Poor Boy's Fund and free-studentship committee.
- Treasurer, Bihar Relief Committee.
- Chairman, Institute of Gandhian Studies, Varanasi.
- Chairman, Indian Council of World Affairs, Bihar Branch.
- Chairman, Bihar Literacy Association, Patna.
- Chairman, Bihar Citizen's Council of Higher Education.
- Member, Bihar Gandhi Smarak Sangrahalaya Samiti.

AS A PERSON

Professor Prasad's mother was generous and father was wise and brave. He imbibed both the qualities from his parents and as such he was upright and all the same, had a very soft heart. As the Professor-in-charge of Poor Boy's Fund and free-Studentship Committee, he helped the needy students who otherwise could not have continued higher education. He took personal interest in student's well-being. Professor Bimbadhar Nayak in "Decade under Beacon light of a great teacher" describes how critical Prof. Prasad was in his approach in awarding free-studentship to students. During his stay in Ravenshaw College he had always a couple of students staying with him. He was a very kind person. He was easily approachable by members of the teaching staff, as well as, non-teaching staff who would often meet him with personal problems. So did his neighbours. He had a strong attachment for his village. During his first twenty years stay in Cuttack, he used to spend about a month in his village during the summer vacation. During his stay in the village he would help the villagers to settle small disputes under his mediation and avoid running to law of courts and getting financially ruined

A staunch nationalist he felt the importance of teaching in mother tongue. All the same he realized that the importance of English should not be diminished. In the university, teaching should be in English. English has been a great factor in the integration and development of science. He advocated the cause of English in the press. He expressed his opinion on social and political matters freely in the press. He believed in integration and was above narrow casteism and provincialism. He believed that inter-caste and inter-provincial marriage would lead to integration. The boy from Cuttack, Banabihari Das, brought up by him as a son, he got married to a girl from Bihar. His own son was married to the daughter of one of his colleague in Ravenshaw College, who was an Oriya Brahmin. His son Shri Krishna Prasad has retired from Indian Forest Service and is currently living with his wife in



Prasad's home at Rajendra Nagar, Patna. Banbehari Das, the Oriya boy he brought up, is dead. His family members are living at Patna in Prof. Prasad's home there. Professor Prasad's wife Smt. Saraswati Devi was a very kind-hearted lady. She earned the respect and love of all the students of her husband through her motherly affection. The co-writer of this memoir (RK Nanda) lived in Prof. Prasad's house for two years during his student days and deeply cherishes the memories of love and affection bestowed on him both by Prof. Prasad and Mrs. Prasad. She was extremely considerate even to the laboratory assistants, attendants and their families. She made minimum demand on Prof. Prasad's time for social engagements and at the same time alert in looking after his health. She preceded him in 1970.

ACKNOWLEDGEMENTS

The authors are thankful to the Academy, Prof. Asish K Ghosh, Science College, Patna and the volume "Essays in Honor of Prof. Balbhadra Prasad" by citizens' forum Patna, for providing valuable information for the preparation of the memoir.

RK NANDA
Retd Professor
Utkal University
137, Lewis Road,
Bhubaneswar-751 014 (Orissa)

S ADITYA
Retd Professor
Calcutta University
Bl.14, Flat 36, 108 MM Road, Kolkata-700 054 (WB)
Phone: 09830226537

BIBLIOGRAHY

- 1933 On the Viscosity of liquids and the dependence of viscosity constants on constitutional factors *Jour Ind Chem Soc* **10** 143.
- Viscosity of liquids their boiling and critical temperature *Jour Ind Chem Soc* **10** 135.
- Viscosity of fused salts and 'Andrade - Sheppard' formula for viscosity of liquids *Phil Mag* **19** 263.
- 1934 Viscosity of Molecular Association *Jour Ind Chem Soc* **11** 913.
- 1935 Viscosity of Dilute Solutions of Non-Electrolytes *Jour Ind Chem Soc* **12** 499.
- 1938 (With CHAKRABARTI AS and PRASAD SN) Viscosity and Density of Aqueous Solution of Mercuric chloride at 35° C *Jour Ind Chem Soc* **15** 301.
- (With CHAKRABARTI AS) Viscosity and Density of cadmium chloride solution at *Jour Ind Chem Soc* **15** 301.
- (With SRINIVASAN MK) Viscosity and Density of Aqueous solution of some weak electrolytes at 35° C *Trans Farad Soc* **34** 1139.
- 1939 (With SRINIVASAN MK) Viscosity and density of aqueous solution of sulphuric acid at 35° C *Trans Farad Soc* **35** 374.
- (With SRINIVASAN MK) Apparent Molal Volume of strong electrolytes in aqueous solutions *Trans Farad Soc* **35** 1462.



- 1939 (With CHAKRAVARTI AS) Viscosity and density of aqueous solutions of Barium Chloride Magnesium chloride Cobalt chloride and Nickel chloride at 35° C *Trans Farad Soc* **55** 1466.
- (With SRINIVASAN MK) Viscosity of aqueous solutions of Formic Cyanoacetic and Oxalic acids *Jour Ind Chem Soc* **16** 371.
- (With SRINIVASAN MK) Viscosity of non-ideal binary liquid mixtures *Jour Ind Chem Soc* **16** 305.
- 1940 (With CHAKRAVARTI AS) viscosity of electrolytic mixture in dilute solution *Trans Farad Soc* **36** 557.
- (With CHAKRAVARTI AS) The effect of hydrochloric acid on the viscosity of Barium and Magnesium Chloride solution *Trans Farad Soc* **36** 561.
- 1941 (With CHAKRAVARTI AS) Apparent molal volume of electrolyte mixture in aqueous solutions *Jour Ind Chem Soc* **18** 239.
- 1942 (With SRINIVASAN MK) The variation of viscosity of liquids with the variation of temperature *Phil Mag* **33** 258.
- 1944 (With PATNAIK T) Viscosity of aqueous solution of Calcium Chloride at 35° C *Jour Ind Chem Soc* **21** 125.
- 1947 (With PATNAIK T) Viscosity of solutions containing an electrolyte and a non-electrolyte *Jour Ind Chem Soc* **24** 163.
- 1948 Irany's temperature function of viscosity *Phil Mag* **39** 645.
- A theory of viscosity and thermal conductance of liquids and highly compressed gases *Phil Mag* **39** 884.
- 1951 (With NATH S and ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part I Lead Nitrate *Jour Ind Chem Soc* **28** 683.
- 1952 (With DAS NK and ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part II Lead Acetate *Jour Ind Chem Soc* **29** 169.
- (With ADITYA S) Potentiometric determination of the solubility product of silver thiocyanate *Jour Ind Chem Soc* **29** 293.
- 1952 (With PARIDA RN and ADITYA S) Potentiometric estimation of Thiocyanate in solution *Jour Ind Chem Soc* **29** 377.
- (With RAMANA RAO DV) Use of ammonium molybdate as a catalyst in the Iodometric Estimation of Ferric Iron *Curr Science* **21** 338.
- (With PANDA S) Apparent Molal volume of sodium and potassium chloride at 35 C *Jour Ind Chem Soc* **29** 907.
- (With NAYAK B and ADITYA S) A study of salt bridge *Jour Ind Chem Soc* **29** 925.
- 1953 (With ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part III Lead Acetate *Jour Ind Chem Soc* **30** 213.
- (With MANGARAJ D and ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part IV Cadmium Nitrate *Jour Ind Chem Soc* **30**.
- (With ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part V Cadmium Acetate *Jour Ind Chem Soc* **30** 255.



- 1953 (With MAHAPATRA P and ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part VI Mercuric Acetate *Jour Ind Chem Soc* **30** 509.
- (With SIRCAR SC and ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part VII Copper Acetate *Jour Ind Chem Soc* **30** 633.
- (With JENA PK and ADITYA S) Studies in the behaviour of bi-univalent salts in aqueous solution Part VIII Nickel Acetate *Jour Ind Chem Soc* **30** 736.
- 1954 (With JENA PK) Studies in the behaviour of bi-univalent salts in aqueous solution Part IX Cadmium Perchlorate *Jour Ind Chem Soc* **31** 431.
- (With SIRCAR SC) Studies in the behaviour of bi-univalent salts in aqueous solution Part X Zinc Perchlorate *Jour Ind Chem Soc* **31** 483.
- 1956 (With JENA PK) Determination of solubility product of Nickel Hydroxide *Jour Ind Chem Soc* **33** 122.
- (With SIRCAR SC) A note on solubility of Copper oxide in Nitric Acid *Jour Ind Chem Soc* **33** 365.
- 1957 (With NAYAK B) Studies in the behaviour of bi-univalent salts in aqueous solution Part XI Barium Acetate *Jour Ind Chem Soc* **34** 640.
- (With NANDA RK) Modified Iodometric Method of estimation of zinc *Jour Ind Chem Soc* **34** 479.
- (With NANDA RK) Estimation of Zinc as Oxalate *Jour Ind Chem Soc* **26** 148.
- 1960 (With JENA PK) Determination of standard electrode potential of $\text{Ag} | \text{Ag}_2\text{CrO}_4, \text{CrO}_4^{2-}$ *Jour Ind Chem Soc* **37** 634.
- 1961 (With SIRCAR SC and JENA PK) Studies in the behaviour of uni-bivalent salts in aqueous solution Part I Potassium Ammonium Sodium and Lithium Sulphate and determination of standard electrode potential of $\text{Hg} | \text{Hg}_2\text{SO}_4, \text{SO}_4^{2-}$ *Jour Ind Chem Soc* **38** 101.
- (With SIRCAR SC) Studies in the behaviour of uni-bivalent salts in aqueous solution Part II Sodium Oxalate and determination of standard electrode potential of $\text{Ag} | \text{Ag}_2\text{C}_2\text{O}_4, \text{C}_2\text{O}_4^{2-}$ *Jour Ind Chem Soc* **38** 361.
- 1962 (With JENA PK) Studies in the behaviour of bi-univalent salts in aqueous solution part I Cadmium Sulphate *Jour Ind Chem Soc* **39** 33.
- 1965 A simple derivation of single-electrode and Redox Potential *Jour Ind Chem Soc* **42** 567.
- 1968 (With SIRCAR SC) Studies in the behaviour of bi-univalent salts in aqueous solution Part II Zinc Sulphate *Jour Ind Chem Soc* **45** 63.
- (With SHARMA L and SAHU G) Standard potential of the cell $\text{Hg} | \text{Hg}_2\text{Cl}_2, \text{HCl} | \text{Q.H} | \text{Pt}$ *Jour Ind Chem Soc* **45** 580.
- (With ACHARYA PC RAY) Incomplete dissociation of salts Memorial lecture *Jour Ind Chem Soc* **45** 1037.
- 1969 (With SAHU G) Ionic equilibria in aqueous solution of Cadmium chloride and the related heat data *Jour Ind Chem Soc* **46** 233.
- (With SHARMA L) The second dissociation constant of Sulphuric acid at a number of temperature and heat of dissociation of HSO_4^- ion *Jour Ind Chem Soc* **46** 241.



- 1969 (With SAHU G) Ionic equilibria in aqueous solution of Cadmium Perochlorate and Cadmium Nitrate *Jour Ind Chem Soc* **46** 910.
- (With SAHU G) Ionic equilibria in aqueous solution of Chlorides of Magnesium Calcium Strontium and Barium *Jour Ind Chem Soc* **46** 933.
- 1970 (With SHARMA L) Solubility product of Hg_2SO_4 at a number of temperature *Jour Ind Chem Soc* **47** 193.
- (With SHARMA L) Standard emf of the cell and the standard electrode potential of Hg $\text{Hg}_2\text{SO}_4^{2-}$, SO_4^{2-} at 5° , 15° , 25° and 35° C *Jour Ind Chem Soc* **47** 379.

$$\text{Pt} | \text{Q.H.}, \text{H}_2\text{SO}_4 \parallel \text{H}_2\text{SO}_4 \parallel \text{H}_2\text{SO}_4, \text{Hg}_2\text{SO}_4 | \text{Hg}$$

$$(c) \qquad (c) \qquad (c)$$
- (With SHARMA L) Ionic equilibria in Trivalent salts and corresponding heats of dissociation I Aluminium Sulphate *Jour Ind Chem Soc* **47** 697.
- (With SINHA HK) Standard emf of the cell $\text{Ag} | \text{AgBr}, \text{HBr} \parallel \text{HBr} \parallel \text{HBr}, \text{QH} | \text{Pt}$ and the standard electrode potential of $\text{Ag} | \text{AgBr}, \text{Br}^-$ at 5° , 15° , 25° and 35° C *Jour Ind Chem Soc* **47** No 9 901.
- 1973 (With CHOUDHARY BK) Standard potential of Cd_xHg_y Cd^{2+} electrode *Jour Ind Chem Soc* **50** 153.
- (With SINHA HK) Ionic equilibria in aqueous solutions of Cadmium Bromide and the related heat data **50** 177.
- (With JHA SN) Ionic equilibria in trivalent salts and corresponding thermodynamics functions: Chromium Sulphate (Chrome Alum) *Proc Nat Acad Sci India* **43(A)** 1 and 2.
- (With CHOUDHARY BK) Standard potential of Mercury Mercurous Acetate electrode at different temperatures and the related thermodynamic functions *Ind Jour Chem* **11** 931.
- 1974 (With SINHA AK and GHOSH JC) Second dissociation constant of Oxalic Acid from 0 to 50 *Jour Ind Chem Soc* **51** 586.
- 1975 (With LAL SC) Standard potential of silver thiocyanate electrode and related thermodynamic functions *Ind Jour Chem* **13** 372.
- 1975 (With JHA SN) Ionic equilibria in trivalent salts and corresponding thermodynamic functions (Indium Alum) *Proc Nat Acad India* **45(A)** 1.
- (With CHOUDHARY BK) Ionic equilibria in aqueous solutions of Cadmium acetate and the related thermodynamic functions *Jour Ind Chem Soc* **52** 679.
- 1976 (With LAL SC) Ionic equilibria of Cadmium thiocyanate in aqueous solutions and the related thermodynamic functions *Jour Ind Chem Soc* **53** 136.
- 1977 Modified Davies equation *Jour Ind Chem Soc* **54** 488.
- 1978 (With JHA AC) A new method for determining solubility product of Silver Bromide *Jour Ind Chem Soc* **55** 301.
- 1979 (With GHOSH AK and GHOSH JC) Second dissociation constant of Phosphoric Acid A recalculation from Alkaline solutions using modified Davies equation *Jour Ind Chem Soc* **56** 489.
- 1980 (With PRASAD AK) Dissociation of PbCl^+ in aqueous solution and related thermodynamic quantities *Jour Ind Chem Soc* **57** 155.



- 1980 (With JHA AC) Determination of solubility product of silver bromide at a number of temperature *Jour Ind Chem Soc* **57** 325.
- (With GHOSH AK and GHOSH JC) Third dissociation constant of Phosphoric acid from 283,5 to 323K *Jour Ind Chem Soc* **57** 1194.
- 1981 (With SINHA AK and GHOSH JC) First dissociation equilibrium of oxalic acid *Jour Ind Chem Soc* **57** 33.
- 1982 (With CHOUDHARY CK) Standard potential of mercury mercurous electrode at a number of temperatures *Jour Ind Chem Soc* **59** 555.
- Standard e.m.f. of the cell
- $$\text{Pb}_x \text{Hg}_y \mid \text{HCl} (m_1) \mid \text{HCl} (m_1) \mid \text{HCl} (m_1) \mid \text{AgCl} \mid \text{Ag}$$
- $$\mid \text{PbCl}_2 (m_2) \mid \text{PbCl}_2 (m_2) \mid \text{PbCl}_2 (m_2) \mid$$

