STUDIES IN HEXAMETAPHOSPHATES: PART II.

A Study of the Complexes Formed by Sodium Hexametaphosphate with Strontium, Barium and Lead Ions by Conductivity Data.

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In an earlier communication (Mehrotra and Dhar, 1949), it has been shown that when sodium hexametaphosphate solutions are shaken with sparingly soluble salts of calcium, then the mixture shows an appreciable increment in specific conductivity. From the order of the increments in specific conductivities, it has been concluded that the dissolution of insoluble calcium salts in sodium hexametaphosphate solutions is due to the following reaction:

$$Na_6(PO_3)_6 + CaX \rightleftharpoons Na_4[Ca(PO_3)_6] + Na_2X.$$

The extent to which the reaction proceeds forward has been shown to depend upon (1) the instability constant of the complex ion formed, (2) the solubility product of the sparingly soluble salt used, and (3) the dilution of the hexametaphosphate solution.

The present communication records the results of similar investigations carried out with the sparingly soluble salts—sulphates of strontium, barium and lead.

Experimental.

Sodium hexametaphosphate solutions were prepared as described in the earlier communication and after measuring their specific conductivity, the solutions were shaken with strontium sulphate, barium sulphate and lead sulphate. The mixtures were shaken vigorously from time to time and were allowed to stand at the room temperature. The specific conductivities of the mixtures were measured on successive days and when the conductivities did not show a variation greater than 1 to 2%, the values were taken as constant. It was observed that the solutions of hexametaphosphate became saturated with strontium and lead sulphates in about 3–4 days, but it took about 6 to 7 days for the solution to get saturated with barium sulphate.

Table 1.

Specific conductivities at 22·5° C. of sodium hexametaphosphate solutions when alone and when saturated with strontium sulphate.

Conc. of sodium hexametaphosphate solution.	Specific Conductivity of the hexametaphosphate solution alone.	Specific Conductivity of the solution when shaken with strontium sulphate.
M/64 ..	0·002486	0·004731
M/128 ..	0·001322	0·002910
M/256 ..	0·000746	0·001772
M/512 ..	0·000403	0·001070
M/1024 ..	0·000213	0·000613
Water ..	$1{\cdot}2 \times 10^{-6}$	0·000140

TABLE 2.

Specific conductivities at 30·0° C. of sodium hexametaphosphate solutions when alone and when saturated with strontium sulphate.

Conc. of sodium hexametaphosphate solution.	Specific Conductivity of the hexametaphosphate solution alone.	Specific Conductivity of the solution when shaken with strontium sulphate.
M/32 ..	0·005966	0·00946
M/64 ..	0·003220	0·005970
M/128 ..	0·001740	0·003540
M/256 ..	0·000964	0·002090
M/512 ..	0·000507	0·001162
M/1024 ..	0·000276	0·000751
Water ..	$1·3 \times 10^{-6}$	0·000171

TABLE 3.

Specific conduc tivitiesat 22·5° C. of sodium hexametaphosphate solutions when alone and when saturated with lead sulphate.

Conc. of sodium hexametaphosphate solution.	Specific Conductivity of the hexametaphosphate solution alone.	Specific Conductivity of the solution when shaken with lead sulphate.
M/64 ..	0·002486	0·004981
M/128 ..	0·001322	0·002990
M/256 ..	0·000746	0·001767
M/512 ..	0·000403	0·001198
M/1024 ..	0·000213	0·000652
Water ..	$1·2 \times 10^{-6}$	0·000051

TABLE 4.

Specific conductivities at 20·0° C. of sodium hexametaphosphate solutions when alone and when saturated with lead sulphate.

Conc. of sodium hexametaphosphate solution.	Specific Conductivity of the hexametaphosphate solution alone.	Specific Conductivity of the solution when shaken with lead sulphate.
M/128 ..	0·001291	0·002880
M/256 ..	0·000710	0·001662
M/512 ..	0·000384	0·001170
M/1024 ..	0·000204	0·000639
Water ..	$1·3 \times 10^{-6}$	0·000044

TABLE 5.

Specific conductivities at 22·5° C. of sodium hexametaphosphate solutions when alone and when saturated with barium sulphate.

Conc. of sodium hexametaphosphate solution.	Specific Conductivity of the hexametaphosphate solution alone.	Specific Conductivity of the solution when shaken with barium sulphate.
M/64 ..	0·002486	0·003031
M/128 ..	0·001322	0·001823
M/256 ..	0·000746	0·001242
M/512 ..	0·000403	0·000788
M/1024 ..	0·000213	0·000439
Water ..	$1·2\times10^{-6}$	$7·3\times10^{-6}$

A perusal of the conductivity data in the Tables 1 to 5 shows that the main reaction in the case of strontium and barium sulphates might be represented by the following equations:

$$Na_6(PO_3)_6+BaSO_4 \rightleftharpoons Na_4[Ba(PO_3)_6]+Na_2SO_4;$$
$$Na_6(PO_3)_6+SrSO_4 \rightleftharpoons Na_4[Sr(PO_3)_6]+Na_2SO_4.$$

However, as discussed in the earlier communication, the reaction goes forward to a greater extent in the case of strontium sulphate (solubility product $= 2·8\times10^{-7}$) that in the case of barium sulphate (solubility product $= 1·2\times10^{-10}$). Moreover, in every case the reaction goes forward to a greater extent as the dilution of the hexametaphosphate solution is increased. In the case of lead sulphate, however, the reaction has a tendency to go to a stage further as represented by the following equations:

$$Na_6(PO_3)_6 \quad +PbSO_4 \rightleftharpoons Na_4[Pb(PO_3)_6]+Na_2SO_4 \text{ and}$$
$$Na_4[Pb(PO_3)_6]+PbSO_4 \rightleftharpoons Na_2[Pb_2(PO_3)_6]+Na_2SO_4.$$

Further work has confirmed the mechanism assumed above.

SUMMARY.

1. The conductivities of solutions of sodium hexametaphosphate of varying strengths have been measured first alone and when saturated with sulphates of strontium, barium and lead.

2. It has been observed that the specific conductivities shows a very large increment when the solutions are shaken with these insoluble salts.

3. From the order of these increments in specific conductivities, it has been concluded that the strontium, barium and lead sulphates dissolve in the sodium hexametaphosphate solutions with the formation of the complex salts—$Na_4Sr(PO_3)_6$, $Na_4Ba(PO_3)_6$ and $Na_4Pb(PO_3)_6$. However only in the case of lead, there is a marked tendency of the reaction to go to a stage further with the formation of the complex—$Na_2Pb_2(PO_3)_6$.

REFERENCES.

Mehrotra and Dhar (1949). Preparation and properties of sodium hexametaphosphate and a study of the extent of complex formation with calcium ions by conductivity data. *Proc. Nat. Inst. Sci. Ind.*, **16**, 59.