SESIUM KLORIDA (CsCl) : TRANSPORT ION DALAM LARUTAN

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Abstrak Sesium klorida adalah senyawa anorganik dengan rumus CsCl. Senyawa ini dapat dengan mudah larut dalam air. Sesium klorida memiliki toksisitas rendah terhadap manusia dan hewan, sedangkan bentuk radioaktif dari senyawa ini dapat dengan mudah mencemari lingkungan karena kelarutan airnya. Senyawa ini digunakan dalam proses sentrifugasi isopiknik dalam pemisahan berbagai jenis DNA dan juga digunakan untuk analisis reagen kimia. Dalam bentuk isotop radio, senyawa ini berguna untuk pengobatan nuklir, yaitu untuk pengobatan kanker. Penelitian ini bertujuan untuk menganalisis interaksi molekuler dan kinetik dari senyawa sesium klorida. Metode yang digunakan adalah dengan pemodelan menggunakan chemoffice serta melalui jurnal hasil penelitian yang berkaitan dengan sesium klorida. Sifat sifat termokimia dari senyawa sesium klorida dalam fase liquid ΔH° : -434.47 KJ/mol, s° : 101.71 J/molK dan ΔG° : -414.5 KJ/mol. Data ini di peroleh dari wikipedia. Parameter transfer elektron adalah kecepatan drift, nomor angkut, mobilitas ion, difusi dan hukum I Fick. **Keyword** : *drift speed, transport number, ion mobility, diffusion and I Fick's law*

I. Introduction

Sesium klorida adalah senyawa anorganik (57) dengan rumus CsCl. Senyawa ini dapat dengan mudah larut dalam air. Sesium klorida memiliki kadar racun yang rendah terhadap manusia dan hewan, sementara bentuk radioaktif (59; 60) dari senyawa ini dapat dengan mudah mencemari lingkungan karena sifatnya yang mudah larut dalam air.

Senyawa ini digunakan dalam proses sentrifugasi (62; 63) isopiknik dalam pemisahan berbagai macam DNA dan juga digunakan untuk reagen (65; 66) kimia analisis. Dalam bentuk radio isotopnya (67) senyawa ini berguna untuk kedokteran nuklir yaitu untuk penanganan kanker.

Sifat sifat termokimia dari senyawa sesium klorida dalam fase liquid ΔH° : -434.47 KJ/mol, s° : 101.71 J/molK dan ΔG° : -414.5 KJ/mol. Mr CsCl: 168.36 g/mol CsCl memiliki konstanta kisi 4,11 Å Data ini di peroleh dari wikipedia

Berbeda dengan natrium klorida dan kalium klorida, senyawa sesium klorida dapat dengan mudah larut dalam asam klorida terkonsentrasi. Sesium klorida ini juga memiliki kelarutan yang relatif tinggi dalam asam format (1077 g / L pada 18 ° C) dan juga dalam hidrazin.

Bentuk dari senyawa ini berupa kisi kristal sederhana yang mana atom Cs^+ dikelilingi oleh 8 atom Cl^- , begitu pula atom Cl^- juga di kelilingi oleh 8 atom Cs^+ . Sehingga susunan kristal ini membentuk kisi kristal sederhana. Bilangan oksidasi Cs dan Cl dalam CsCl adalah 8.

Dalam tabel periodik unsur, yang umumnya membentuk ikatan ionik adalah unsur pada golongan alkali dan alkali tanah dengan unsur unsur dari golongan halogen. Namun ada pengecualian pada atom Cs yang mana atom ini memiliki keelektronegativan terendah sehingga ikatan ionik yang terbentukpun tidak sepenuhnya ionik.

Parameter transfer ion berupa kecepatan hanyut, bilangan transport, mobilitas ion, difusi dan hukum I Fick dari senyawa sesium klorida ini

II. Metode

Metode yang digunakan adalah komputasi dan perhitungan matematika. Proses ini bertujuan untuk mengetahui dan memahami struktur dan karakteristik senyawa CsCl digunakan data yang diperoleh dari aplikasi Chem Draw profesional 15.0 dan Chem 3D dan juga melalui data jurnal penelitian. Proses menganalisis menggunakan chemdraw yaitu dengan menghitung MM2 dari molekul CsCl yang terdiri dari MM2 minimization, MM2 dynamics dan MM2 properties.

Sifat fisika dan kimia dari senyawa ini di dapat dari wikipedia. CsCl berupa padatan berwarna putih dan larut dalam air serta larut dalam etanol. Massa molar : 168.36 g/mol Penampilan: padat putih Densitas : 3.988 g/cm³ Titik didih: 1;297 °C (2;367 °F; 1;570 K) Kelarutan dalam air: 1910 g/L (25 °C)

Cesium klorida terjadi secara alami sebagai pengotor dalam mineral halida karnalit. Pada skala industri, CsCl diproduksi dari mineral pollucite, yang bubuk dan direaksikan dengan asam hidroklorida pada suhu tinggi. Ekstrak ini direaksikan lagi dengan antimon klorida, yodium monoklorida, atau cerium (IV) klorida untuk memberikan garam ganda yang kelarutannya buruk.

III. Hasil dan Pembahasan

gambar 1. Sesium clorida dalam bentuk kristal
sumber 1. https://id.wikipedia.org/wiki/Sesium_klorida

1. Karakteristik Senyawa Sesium Clorida

Gambar 2. Pemodelan CsCl

Gambar 3. Struktur dengan permukaan translucent

Gambar 4. Struktur dengan Wire maash

Rumus kimia	: CsCl
Massa molar	: 168.36 g/mol
Penampilan	: padat putih
Densitas	: 3.988 g/cm ³
Titik didih	: 1;297 °C (2;367 °F; 1;570 K)
Kelarutan dalam air	: 1910 g/L (25 °C)
Struktur kristal	: CsCl, cP2
Geometri koordinasi	: Kubik (Cs ⁺) Kubik (Cl ⁻)
Jenis ikatan(68; 69)	: ikatan ion
ΔH° (70; 71)	: -434.47 KJ/mol
s° (72-74)	: 101.71 J/molK
ΔG° (75; 76)	: -414.5 KJ/mol ΔG° : -414.5 KJ/mol

1. Optimasi MM2

MM2 Calculation completed successfully

-----MM2 Minimization-----

Warning: The number of ligands attached does not match the geometry of Si(3)

Warning: Some parameters are guessed (Quality = 1).

Iteration	1	Steric Energy	-122.130	RMS Gradient	23.993	RMS Move	0.0000
Iteration	2	Steric Energy	-212.644	RMS Gradient	57.470	RMS Move	0.2041
Iteration	3	Steric Energy	-221.997	RMS Gradient	41.854	RMS Move	0.0385
Iteration	4	Steric Energy	-233.539	RMS Gradient	18.147	RMS Move	0.0309
Iteration	5	Steric Energy	-236.236	RMS Gradient	12.682	RMS Move	0.0149
Iteration	6	Steric Energy	-237.883	RMS Gradient	9.204	RMS Move	0.0099
Iteration	7	Steric Energy	-239.990	RMS Gradient	12.894	RMS Move	0.0276
Iteration	8	Steric Energy	-241.259	RMS Gradient	11.827	RMS Move	0.0151
Iteration	9	Steric Energy	-245.166	RMS Gradient	7.373	RMS Move	0.0433
Iteration	10	Steric Energy	-249.577	RMS Gradient	20.063	RMS Move	0.0883
Iteration	11	Steric Energy	-252.310	RMS Gradient	13.393	RMS Move	0.0408
Iteration	12	Steric Energy	-254.918	RMS Gradient	14.926	RMS Move	0.0590
Iteration	13	Steric Energy	-256.360	RMS Gradient	11.614	RMS Move	0.0171
Iteration	14	Steric Energy	-259.908	RMS Gradient	9.477	RMS Move	0.0434
Iteration	15	Steric Energy	-261.062	RMS Gradient	12.019	RMS Move	0.0199
Iteration	16	Steric Energy	-263.318	RMS Gradient	12.278	RMS Move	0.0530
Iteration	17	Steric Energy	-264.950	RMS Gradient	10.294	RMS Move	0.0215
Iteration	18	Steric Energy	-267.166	RMS Gradient	16.546	RMS Move	0.0380
Iteration	19	Steric Energy	-269.278	RMS Gradient	15.579	RMS Move	0.0449
Iteration	20	Steric Energy	-272.384	RMS Gradient	16.636	RMS Move	0.0401
Iteration	21	Steric Energy	-274.247	RMS Gradient	11.700	RMS Move	0.0156
Iteration	22	Steric Energy	-275.567	RMS Gradient	7.169	RMS Move	0.0089
Iteration	23	Steric Energy	-277.247	RMS Gradient	13.699	RMS Move	0.0280
Iteration	24	Steric Energy	-279.058	RMS Gradient	21.192	RMS Move	0.0425
Iteration	25	Steric Energy	-285.299	RMS Gradient	19.689	RMS Move	0.0695
Iteration	26	Steric Energy	-291.627	RMS Gradient	24.747	RMS Move	0.0717
Iteration	27	Steric Energy	-293.837	RMS Gradient	16.321	RMS Move	0.0395
Iteration	28	Steric Energy	-295.347	RMS Gradient	8.694	RMS Move	0.0063
Iteration	29	Steric Energy	-296.119	RMS Gradient	8.327	RMS Move	0.0077
Iteration	30	Steric Energy	-296.667	RMS Gradient	4.592	RMS Move	0.0050
Iteration	31	Steric Energy	-297.380	RMS Gradient	6.134	RMS Move	0.0178
Iteration	32	Steric Energy	-297.619	RMS Gradient	6.410	RMS Move	0.0093
Iteration	33	Steric Energy	-297.785	RMS Gradient	4.072	RMS Move	0.0032
Iteration	34	Steric Energy	-297.896	RMS Gradient	2.270	RMS Move	0.0019
Iteration	35	Steric Energy	-298.214	RMS Gradient	2.323	RMS Move	0.0106
Iteration	36	Steric Energy	-298.358	RMS Gradient	4.346	RMS Move	0.0081
Iteration	37	Steric Energy	-298.614	RMS Gradient	4.877	RMS Move	0.0173
Iteration	38	Steric Energy	-298.802	RMS Gradient	2.945	RMS Move	0.0072
Iteration	39	Steric Energy	-298.933	RMS Gradient	2.894	RMS Move	0.0045
Iteration	40	Steric Energy	-299.307	RMS Gradient	2.453	RMS Move	0.0175
Iteration	41	Steric Energy	-299.405	RMS Gradient	2.784	RMS Move	0.0082
Iteration	42	Steric Energy	-299.478	RMS Gradient	1.709	RMS Move	0.0052
Iteration	43	Steric Energy	-299.616	RMS Gradient	3.021	RMS Move	0.0177
Iteration	44	Steric Energy	-299.855	RMS Gradient	3.926	RMS Move	0.0305
Iteration	45	Steric Energy	-299.945	RMS Gradient	3.145	RMS Move	0.0150
Iteration	46	Steric Energy	-300.055	RMS Gradient	3.246	RMS Move	0.0169
Iteration	47	Steric Energy	-300.112	RMS Gradient	2.625	RMS Move	0.0036
Iteration	48	Steric Energy	-300.214	RMS Gradient	2.222	RMS Move	0.0067

Iteration 49 Steric Energy -300.270 RMS Gradient 2.133 RMS Move 0.0039
 Iteration 50 Steric Energy -300.305 RMS Gradient 1.099 RMS Move 0.0019

Stretch : 0.4136
 Bend : 6.9206
 Stretch-Bend : -0.6266
 Torsion : 19.8219
 Non-1,4 VDW : 61.4635
 1,4 VDW : 1.0594
 Charge/Charge : -424.9349
 Charge/Dipole : -15.6811
 Total Energy : -351.5636 kcal/mol

Note: Due to high VDW interactions, some terms were not computed.
 Calculation ended

 MM2 Calculation completed successfully

-----MM2 Dynamics-----

Warning: The number of ligands attached does not match the geometry of Si(3)

Warning: Some parameters are guessed (Quality = 1).

Iteration	Time	Total Energy	Potential Energy	Temperature
1	0.002	-351.564 ± 0.000	-351.564 ± 0.000	0.00 ± 0.00
2	0.004	-351.551 ± 0.000	-351.557 ± 0.000	0.26 ± 0.00
3	0.006	-351.539 ± 0.000	-351.551 ± 0.000	0.52 ± 0.00
4	0.008	-351.518 ± 0.000	-351.552 ± 0.000	1.44 ± 0.00
5	0.010	-351.516 ± 0.000	-351.553 ± 0.000	1.56 ± 0.00
6	0.012	-351.508 ± 0.000	-351.555 ± 0.000	1.96 ± 0.00
7	0.014	-351.488 ± 0.000	-351.544 ± 0.000	2.31 ± 0.00
8	0.016	-351.484 ± 0.000	-351.541 ± 0.000	2.39 ± 0.00
9	0.018	-351.441 ± 0.000	-351.497 ± 0.000	2.35 ± 0.00
10	0.020	-351.421 ± 0.000	-351.489 ± 0.000	2.86 ± 0.00
11	0.022	-351.402 ± 0.000	-351.525 ± 0.000	5.14 ± 0.00
12	0.024	-351.387 ± 0.000	-351.475 ± 0.000	3.67 ± 0.00
13	0.026	-351.381 ± 0.000	-351.516 ± 0.000	5.69 ± 0.00
14	0.028	-351.366 ± 0.000	-351.504 ± 0.000	5.80 ± 0.00
15	0.030	-351.358 ± 0.000	-351.457 ± 0.000	4.15 ± 0.00
16	0.032	-351.353 ± 0.000	-351.506 ± 0.000	6.43 ± 0.00
17	0.034	-351.327 ± 0.000	-351.469 ± 0.000	5.92 ± 0.00
18	0.036	-351.328 ± 0.000	-351.459 ± 0.000	5.48 ± 0.00
19	0.038	-351.320 ± 0.000	-351.489 ± 0.000	7.08 ± 0.00
20	0.040	-351.318 ± 0.000	-351.431 ± 0.000	4.74 ± 0.00
21	0.042	-351.323 ± 0.000	-351.450 ± 0.000	5.34 ± 0.00
22	0.044	-351.304 ± 0.000	-351.446 ± 0.000	5.94 ± 0.00
23	0.046	-351.305 ± 0.000	-351.392 ± 0.000	3.65 ± 0.00
24	0.048	-351.295 ± 0.000	-351.442 ± 0.000	6.14 ± 0.00
25	0.050	-351.249 ± 0.000	-351.417 ± 0.000	7.03 ± 0.00
26	0.052	-351.261 ± 0.000	-351.420 ± 0.000	6.65 ± 0.00
27	0.054	-351.245 ± 0.000	-351.464 ± 0.000	9.18 ± 0.00
28	0.056	-351.225 ± 0.000	-351.381 ± 0.000	6.51 ± 0.00
29	0.058	-351.226 ± 0.000	-351.438 ± 0.000	8.88 ± 0.00
30	0.060	-351.214 ± 0.000	-351.468 ± 0.000	10.67 ± 0.00
31	0.062	-351.219 ± 0.000	-351.415 ± 0.000	8.20 ± 0.00

32	0.064	-351.215 ± 0.000	-351.445 ± 0.000	9.66 ± 0.00
33	0.066	-351.202 ± 0.000	-351.425 ± 0.000	9.35 ± 0.00
34	0.068	-351.189 ± 0.000	-351.397 ± 0.000	8.75 ± 0.00
35	0.070	-351.168 ± 0.000	-351.426 ± 0.000	10.83 ± 0.00
36	0.072	-351.164 ± 0.000	-351.368 ± 0.000	8.55 ± 0.00
37	0.074	-351.156 ± 0.000	-351.366 ± 0.000	8.82 ± 0.00
38	0.076	-351.152 ± 0.000	-351.424 ± 0.000	11.42 ± 0.00
39	0.078	-351.139 ± 0.000	-351.404 ± 0.000	11.12 ± 0.00
40	0.080	-351.138 ± 0.000	-351.435 ± 0.000	12.44 ± 0.00
41	0.082	-351.120 ± 0.000	-351.412 ± 0.000	12.24 ± 0.00
42	0.084	-351.117 ± 0.000	-351.382 ± 0.000	11.14 ± 0.00
43	0.086	-351.109 ± 0.000	-351.444 ± 0.000	14.08 ± 0.00
44	0.088	-351.087 ± 0.000	-351.404 ± 0.000	13.31 ± 0.00
45	0.090	-351.076 ± 0.000	-351.359 ± 0.000	11.87 ± 0.00
46	0.092	-351.066 ± 0.000	-351.361 ± 0.000	12.38 ± 0.00
47	0.094	-351.055 ± 0.000	-351.299 ± 0.000	10.20 ± 0.00
48	0.096	-351.043 ± 0.000	-351.314 ± 0.000	11.35 ± 0.00
49	0.098	-351.029 ± 0.000	-351.288 ± 0.000	10.88 ± 0.00
50	0.100	-351.011 ± 0.000	-351.210 ± 0.000	8.36 ± 0.00

MM2 Calculation completed successfully

-----MM2 Minimization-----

Warning: The number of ligands attached does not match the geometry of Cs(1)

Warning: The number of ligands attached does not match the geometry of Cl(2)

Warning: Some parameters are guessed (Quality = 1).

Iteration 1 Steric Energy 0.000 RMS Gradient 0.000 RMS Move 0.0000

Iteration 2 Steric Energy 0.000 RMS Gradient 0.000 RMS Move 0.0000

Iteration 2: Minimization terminated normally because the gradient norm is less than the minimum
gradient norm

Stretch : 0.0000

Bend : 0.0000

Stretch-Bend : 0.0000

Torsion : 0.0000

Non-1,4 VDW : 0.0000

1,4 VDW : 0.0000

Charge/Charge : 0.0000

Total Energy: 0.0000 kcal/mol

Calculation ended

2. Optimasi

MM2 Calculation completed successfully

-----MM2 Minimization-----

Warning: The number of ligands attached does not match the geometry of Si(3)

Warning: Some parameters are guessed (Quality = 1).

Iteration 1 Steric Energy -122.130 RMS Gradient 23.993 RMS Move 0.0000

Iteration 2 Steric Energy -212.644 RMS Gradient 57.470 RMS Move 0.2041

Iteration 3 Steric Energy -221.997 RMS Gradient 41.854 RMS Move 0.0385

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Iteration 5 Steric Energy -236.236 RMS Gradient 12.682 RMS Move 0.0149

Iteration 6 Steric Energy -237.883 RMS Gradient 9.204 RMS Move 0.0099

Iteration 7 Steric Energy -239.990 RMS Gradient 12.894 RMS Move 0.0276

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Iteration	45	Steric Energy	-299.945	RMS Gradient	3.145	RMS Move	0.0150
Iteration	46	Steric Energy	-300.055	RMS Gradient	3.246	RMS Move	0.0169
Iteration	47	Steric Energy	-300.112	RMS Gradient	2.625	RMS Move	0.0036
Iteration	48	Steric Energy	-300.214	RMS Gradient	2.222	RMS Move	0.0067
Iteration	49	Steric Energy	-300.270	RMS Gradient	2.133	RMS Move	0.0039
Iteration	50	Steric Energy	-300.305	RMS Gradient	1.099	RMS Move	0.0019

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Bend	: 6.9206
Stretch-Bend	: -0.6266
Torsion	: 19.8219
Non-1,4 VDW	: 61.4635
1,4 VDW	: 1.0594
Charge/Charge	: -424.9349
Charge/Dipole	: -15.6811
Total Energy	: -351.5636 kcal/mol

Note: Due to high VDW interactions, some terms were not computed.
Calculation ended

MM2 Calculation completed successfully

-----MM2 Dynamics-----

Warning: The number of ligands attached does not match the geometry of Si(3)

Warning: Some parameters are guessed (Quality = 1).

Iteration Time Total Energy Potential Energy Temperature

1	0.002	-351.564 ± 0.000	-351.564 ± 0.000	0.00 ± 0.00
2	0.004	-351.551 ± 0.000	-351.557 ± 0.000	0.26 ± 0.00
3	0.006	-351.539 ± 0.000	-351.551 ± 0.000	0.52 ± 0.00
4	0.008	-351.518 ± 0.000	-351.552 ± 0.000	1.44 ± 0.00
5	0.010	-351.516 ± 0.000	-351.553 ± 0.000	1.56 ± 0.00
6	0.012	-351.508 ± 0.000	-351.555 ± 0.000	1.96 ± 0.00
7	0.014	-351.488 ± 0.000	-351.544 ± 0.000	2.31 ± 0.00
8	0.016	-351.484 ± 0.000	-351.541 ± 0.000	2.39 ± 0.00
9	0.018	-351.441 ± 0.000	-351.497 ± 0.000	2.35 ± 0.00
10	0.020	-351.421 ± 0.000	-351.489 ± 0.000	2.86 ± 0.00
11	0.022	-351.402 ± 0.000	-351.525 ± 0.000	5.14 ± 0.00
12	0.024	-351.387 ± 0.000	-351.475 ± 0.000	3.67 ± 0.00
13	0.026	-351.381 ± 0.000	-351.516 ± 0.000	5.69 ± 0.00
14	0.028	-351.366 ± 0.000	-351.504 ± 0.000	5.80 ± 0.00
15	0.030	-351.358 ± 0.000	-351.457 ± 0.000	4.15 ± 0.00
16	0.032	-351.353 ± 0.000	-351.506 ± 0.000	6.43 ± 0.00
17	0.034	-351.327 ± 0.000	-351.469 ± 0.000	5.92 ± 0.00
18	0.036	-351.328 ± 0.000	-351.459 ± 0.000	5.48 ± 0.00
19	0.038	-351.320 ± 0.000	-351.489 ± 0.000	7.08 ± 0.00
20	0.040	-351.318 ± 0.000	-351.431 ± 0.000	4.74 ± 0.00
21	0.042	-351.323 ± 0.000	-351.450 ± 0.000	5.34 ± 0.00
22	0.044	-351.304 ± 0.000	-351.446 ± 0.000	5.94 ± 0.00
23	0.046	-351.305 ± 0.000	-351.392 ± 0.000	3.65 ± 0.00
24	0.048	-351.295 ± 0.000	-351.442 ± 0.000	6.14 ± 0.00
25	0.050	-351.249 ± 0.000	-351.417 ± 0.000	7.03 ± 0.00
26	0.052	-351.261 ± 0.000	-351.420 ± 0.000	6.65 ± 0.00
27	0.054	-351.245 ± 0.000	-351.464 ± 0.000	9.18 ± 0.00
28	0.056	-351.225 ± 0.000	-351.381 ± 0.000	6.51 ± 0.00
29	0.058	-351.226 ± 0.000	-351.438 ± 0.000	8.88 ± 0.00
30	0.060	-351.214 ± 0.000	-351.468 ± 0.000	10.67 ± 0.00
31	0.062	-351.219 ± 0.000	-351.415 ± 0.000	8.20 ± 0.00
32	0.064	-351.215 ± 0.000	-351.445 ± 0.000	9.66 ± 0.00
33	0.066	-351.202 ± 0.000	-351.425 ± 0.000	9.35 ± 0.00
34	0.068	-351.189 ± 0.000	-351.397 ± 0.000	8.75 ± 0.00
35	0.070	-351.168 ± 0.000	-351.426 ± 0.000	10.83 ± 0.00
36	0.072	-351.164 ± 0.000	-351.368 ± 0.000	8.55 ± 0.00
37	0.074	-351.156 ± 0.000	-351.366 ± 0.000	8.82 ± 0.00
38	0.076	-351.152 ± 0.000	-351.424 ± 0.000	11.42 ± 0.00
39	0.078	-351.139 ± 0.000	-351.404 ± 0.000	11.12 ± 0.00
40	0.080	-351.138 ± 0.000	-351.435 ± 0.000	12.44 ± 0.00
41	0.082	-351.120 ± 0.000	-351.412 ± 0.000	12.24 ± 0.00
42	0.084	-351.117 ± 0.000	-351.382 ± 0.000	11.14 ± 0.00
43	0.086	-351.109 ± 0.000	-351.444 ± 0.000	14.08 ± 0.00
44	0.088	-351.087 ± 0.000	-351.404 ± 0.000	13.31 ± 0.00
45	0.090	-351.076 ± 0.000	-351.359 ± 0.000	11.87 ± 0.00
46	0.092	-351.066 ± 0.000	-351.361 ± 0.000	12.38 ± 0.00
47	0.094	-351.055 ± 0.000	-351.299 ± 0.000	10.20 ± 0.00
48	0.096	-351.043 ± 0.000	-351.314 ± 0.000	11.35 ± 0.00

49	0.098	-351.029 ± 0.000	-351.288 ± 0.000	10.88 ± 0.00
50	0.100	-351.011 ± 0.000	-351.210 ± 0.000	8.36 ± 0.00

MM2 Calculation completed successfully

-----MM2 Minimization-----

Warning: The number of ligands attached does not match the geometry of Cs(1)

Warning: The number of ligands attached does not match the geometry of Cl(2)

Warning: Some parameters are guessed (Quality = 1).

Iteration	1	Steric Energy	0.000	RMS Gradient	0.000	RMS Move	0.0000
-----------	---	---------------	-------	--------------	-------	----------	--------

Iteration	2	Steric Energy	0.000	RMS Gradient	0.000	RMS Move	0.0000
-----------	---	---------------	-------	--------------	-------	----------	--------

Iteration 2: Minimization terminated normally because the gradient norm is less than the minimum

gradient norm

Stretch	:	0.0000
---------	---	--------

Bend	:	0.0000
------	---	--------

Stretch-Bend	:	0.0000
--------------	---	--------

Torsion	:	0.0000
---------	---	--------

Non-1,4 VDW	:	0.0000
-------------	---	--------

1,4 VDW	:	0.0000
---------	---	--------

Charge/Charge	:	0.0000
---------------	---	--------

Total Energy	:	0.0000 kcal/mol
--------------	---	-----------------

Calculation ended

MM2 Calculation completed successfully

-----MM2 Dynamics-----

Warning: The number of ligands attached does not match the geometry of Cs(1)

Warning: The number of ligands attached does not match the geometry of Cl(2)

Warning: Some parameters are guessed (Quality = 1).

Iteration	Time	Total Energy	Potential Energy	Temperature
-----------	------	--------------	------------------	-------------

1	0.002	0.000 ± 0.000	0.000 ± 0.000	0.00 ± 0.00
2	0.004	0.009 ± 0.000	0.001 ± 0.000	1.32 ± 0.00
3	0.006	0.012 ± 0.000	0.005 ± 0.000	1.25 ± 0.00
4	0.008	0.023 ± 0.000	0.013 ± 0.000	1.79 ± 0.00
5	0.010	0.029 ± 0.000	0.022 ± 0.000	1.04 ± 0.00
6	0.012	0.040 ± 0.000	0.035 ± 0.000	0.84 ± 0.00
7	0.014	0.043 ± 0.000	0.042 ± 0.000	0.06 ± 0.00
8	0.016	0.047 ± 0.000	0.047 ± 0.000	0.01 ± 0.00
9	0.018	0.055 ± 0.000	0.029 ± 0.000	4.29 ± 0.00
10	0.020	0.063 ± 0.000	0.009 ± 0.000	8.98 ± 0.00
11	0.022	0.065 ± 0.000	0.000 ± 0.000	10.91 ± 0.00
12	0.024	0.073 ± 0.000	0.008 ± 0.000	10.89 ± 0.00
13	0.026	0.084 ± 0.000	0.034 ± 0.000	8.42 ± 0.00
14	0.028	0.086 ± 0.000	0.064 ± 0.000	3.62 ± 0.00
15	0.030	0.088 ± 0.000	0.085 ± 0.000	0.44 ± 0.00
16	0.032	0.095 ± 0.000	0.095 ± 0.000	0.02 ± 0.00
17	0.034	0.098 ± 0.000	0.072 ± 0.000	4.36 ± 0.00
18	0.036	0.100 ± 0.000	0.036 ± 0.000	10.86 ± 0.00
19	0.038	0.109 ± 0.000	0.006 ± 0.000	17.18 ± 0.00
20	0.040	0.125 ± 0.000	0.002 ± 0.000	20.60 ± 0.00
21	0.042	0.126 ± 0.000	0.029 ± 0.000	16.37 ± 0.00
22	0.044	0.136 ± 0.000	0.075 ± 0.000	10.21 ± 0.00
23	0.046	0.138 ± 0.000	0.118 ± 0.000	3.31 ± 0.00
24	0.048	0.138 ± 0.000	0.137 ± 0.000	0.03 ± 0.00

25	0.050	0.139 ± 0.000	0.132 ± 0.000	1.20 ± 0.00
26	0.052	0.142 ± 0.000	0.094 ± 0.000	8.06 ± 0.00
27	0.054	0.150 ± 0.000	0.041 ± 0.000	18.24 ± 0.00
28	0.056	0.152 ± 0.000	0.005 ± 0.000	24.67 ± 0.00
29	0.058	0.154 ± 0.000	0.005 ± 0.000	24.99 ± 0.00
30	0.060	0.157 ± 0.000	0.042 ± 0.000	19.41 ± 0.00
31	0.062	0.170 ± 0.000	0.102 ± 0.000	11.38 ± 0.00
32	0.064	0.178 ± 0.000	0.158 ± 0.000	3.43 ± 0.00
33	0.066	0.185 ± 0.000	0.185 ± 0.000	0.02 ± 0.00
34	0.068	0.186 ± 0.000	0.172 ± 0.000	2.36 ± 0.00
35	0.070	0.195 ± 0.000	0.110 ± 0.000	14.25 ± 0.00
36	0.072	0.199 ± 0.000	0.040 ± 0.000	26.65 ± 0.00
37	0.074	0.210 ± 0.000	0.002 ± 0.000	34.96 ± 0.00
38	0.076	0.222 ± 0.000	0.017 ± 0.000	34.43 ± 0.00
39	0.078	0.223 ± 0.000	0.078 ± 0.000	24.22 ± 0.00
40	0.080	0.230 ± 0.000	0.158 ± 0.000	12.04 ± 0.00
41	0.082	0.232 ± 0.000	0.218 ± 0.000	2.34 ± 0.00
42	0.084	0.232 ± 0.000	0.230 ± 0.000	0.34 ± 0.00
43	0.086	0.235 ± 0.000	0.182 ± 0.000	8.94 ± 0.00
44	0.088	0.237 ± 0.000	0.101 ± 0.000	22.84 ± 0.00
45	0.090	0.244 ± 0.000	0.027 ± 0.000	36.42 ± 0.00
46	0.092	0.248 ± 0.000	0.000 ± 0.000	41.57 ± 0.00
47	0.094	0.267 ± 0.000	0.039 ± 0.000	38.36 ± 0.00
48	0.096	0.282 ± 0.000	0.130 ± 0.000	25.39 ± 0.00
49	0.098	0.292 ± 0.000	0.233 ± 0.000	9.99 ± 0.00
50	0.100	0.295 ± 0.000	0.292 ± 0.000	0.54 ± 0.00

Translational Kinetic Energy: 0.0000 Rotational Kinetic Energy: 0.0000

Calculation ended

Sesium klorida (77; 78) merupakan senyawa anorganik (57) yang berbentuk padat berwarna putih yang dapat larut dalam air dan etanol (79; 80). Senyawa ini bersifat higroskopik (81-83) yang berarti mampu menyerap molekul (84; 85) air yang ada di sekitarnya atau lingkungan.

grafik 1. Densitas CsCl di dalam larutan

sumber 2. https://www.researchgate.net/figure/Density-of-CsCl-aqueous-solutions-as-a-function-of-CsCl-concentration_fig1_257993884

Bentuk Molekul Sesium Klorida

Kristal (86; 87) dari senyawa ionik terbentuk karena susunan dari kation dan anion yang terus berulang. Pola penyusunan ion ini menghasilkan kisi kristal (88) dalam bentuk tertentu pula. Sesium klorida merupakan salah satu contoh dari bentuk kisi kristal tersebut. Sesium klorida merupakan senyawa ionik (89; 90) yang terdiri dari ion Cs^+ dan ion Cl^- .

Kisi kristal sesium klorida ini bukan merupakan bentuk kubus berpusat badan atau Body Center Cubic (BCC) melainkan berbentuk kubus sederhana atau primitif cubic.

Figure 1. (kiri) bentuk kisi kristal CsCl, (kanan) bentuk sel tunggal CsCl
sumber 3. <http://www.ilpi.com/inorganic/structures/cscl/index.html>

Atom Cs^+ dikelilingi oleh 8 atom Cl^- , begitu pula atom Cl^- juga di kelilingi oleh 8 atom Cs^+ . Sehingga susunan kristal ini membentuk kisi kristal sederhana.

Atom penyusun sesium klorida

➤ **Sesium**

sumber 4. <https://en.wikipedia.org/wiki/Caesium>
gambar 5. Logam Sesium

Jari-jari atom	: empiris: 265 pm
Jari-jari kovalen	: 244 ± 11 pm
Titik didih	: 944 K (671 °C, 1240 °F)
Titik lebur	: 301.59 K (28.44 °C, 83.19 °F) (https://id.wikipedia.org/wiki/Sesium)

Sesium (91-94) merupakan logam alkali (47; 95) yang memiliki no atom 55 dan berbentuk cair dalam suhu kamar berwarna putih keemasan. Sesium adalah logam alkali yang terdapat di *lepidolite* (96), *pollucite* (silikat aluminum dan Sesium basah) dan di sumber-sumber lainnya. Salah satu tempat yang menjadi sumber terkaya yang mengandung Sesium terdapat di danau Bernic di Manitoba, Kanada. Deposit di danau ini diperkirakan mengandung 300.000 ton *pollucite* yang mengandung 20% Sesium. Unsur ini juga dapat diisolasi dengan cara elektrolisis (97; 98) fusi sianida dan dengan beberapa metoda lainnya. Kegunaan yang paling terkenal dari senyawa ini adalah jam atom. Jam atom ini digunakan oleh ilmuwan sebagai referensi untuk memantau waktu tempuh riset dengan sangat tepat.

➤ **Klorida**

Jari-jari atom	: empiris: <u>100 pm</u> perhitungan: <u>79 pm</u>
Jari-jari kovalen	: <u>99 pm</u>
Titik didih	: 239,11 K (-34,4 °C, -29,27 °F)
Titik lebur	: 171,6 K (-101,5 °C, -150,7 °F) (https://id.wikipedia.org/wiki/Klor)

Ion Klorida (Cl^-) adalah sebuah anion (99-101) yang membentuk bagian yang bermuatan negatif dari garam tertentu, termasuk garam natrium (102; 103) dan hidrogen klorida, dan juga

merupakan elektrolit (104) penting yang terletak di semua cairan tubuh yang bertanggung jawab untuk menjaga keseimbangan asam (105; 106) / basa, transmisi impuls (107) saraf dan juga mengatur cairan masuk dan keluar sel (108; 109). Ion klorida ini banyak terdapat di air laut dimana air laut mengandung 1,94% ion klorida. Berikut adalah reaksi dari sintesis ion klorida :

2. *Sumber*

Di alam senyawa CsCl di dapati menjadi pengotor dalam mineral karnalit, silvit dan kainit.

3. *Sintesis*

Di bidang industri, CsCl dibuat dari mineral (110) polusit. Ekstraknya direaksikan dengan antimon triklorida (111; 112), iodin monoklorida atau serium (IV) klorida untuk memperoleh garam yang sulit larut:

Reaksi garam ini dengan hidrogen sulfida akan menghasilkan CsCl:

4. *Kegunaan Cscl*

CsCl digunakan secara luas dalam sentrifugasi isopiknik yang berguna untuk pemisahan berbagai jenis DNA. Cesium klorida banyak digunakan dalam sentrifugasi. Teknik yang dikenal sebagai sentrifugasi isopycnic. Pemisahan campuran berdasarkan kepadatan molekulernya dapat dilihat melalui gaya sentripetal dan difusif yang membentuk gradien densitas. Teknik ini memungkinkan pemisahan DNA dengan kepadatan berbeda (misalnya fragmen DNA dengan konten A-T atau G-C yang berbeda). Aplikasi ini membutuhkan solusi dengan kerapatan tinggi dan viskositas yang relatif rendah sehingga CsCl cocok karena kelarutannya yang tinggi dalam air, kepadatan tinggi karena massa Cs yang besar, serta viskositas rendah dan stabilitas tinggi.

Dalam bidang kimia analitik CsCl digunakan untuk mendeteksi ion anorganik melalui warna dan morfologi endapan(113; 114). Radioisotop dari CsCl ini berguna dalam bidang medis seperti untuk pengobatan kanker.

5. *Parameter Transfer Ion*

a. *Transport Ion*

Gerakan ion dalam larutan dapat dipelajari dengan mengukur konduktivitas listrik dan larutan elektrolit. Migrasi kation menuju elektroda(105; 106) bermuatan negatif dan anion menuju elektroda bermuatan positif, membawa muatan melalui larutan dan karenanya merupakan proses transport.

Pergerakan Ion Dalam Larutan

Dalam air, ion tidak mungkin berdiri sendiri namun dalam keadaan tersolvasi (115; 116) atau terbungkus oleh molekul air. Misalnya dalam senyawa CsCl, ion Cl^- akan tersolvasi oleh molekul air.

Ion tersolvasi bergerak (aturan antivasi antara anoda dan katoda) dengan kecepatan yang berbeda sesuai dengan ukuran dan muatan . Macam macam pergerakan ion dalam larutan :

- Migrasi (117; 118) terjadi akibat pengaruh potensial
- Difusi terjadi akibat pengaruh konsentrasi (119)
- Konveksi terjadi akibat pengaruh termal (120-123)

b. Mobilitas Dan Konduktivitas

Pengukuran dasar yang digunakan untuk mempelajari gerakan ion adalah pengukuran tahanan listrik larutan. Konduktivitas larutan bergantung pada jumlah ion yang ada dan kita biasa memperkenalkan **konduktivitas molar** Λ_m , yang didefinisikan sebagai:

$$\Lambda_m = \frac{K}{c} \quad (1)$$

Konduktivitas (124-126) molar (127-129) elektrolit, tidak bergantung pada konsentrasi jika k tepat sebanding dengan konsentrasi. Misalnya konsentrasi ion dalam larutan asam lemah bergantung pada konsentrasi asam secara rumit, dan pendua kalian konsentrasi nomial asam itu tidak mendua-kalikan jumlah tersebut. Kedua karena ion saling berantaraksi dengan kuat maka konduktivitas larutan tidak tepat sebandig dengan jumlah ion yang ada.

Konduktivitas biasanya tersedia dalam S Cm^{-1} dan konsentrasi dalam M. Sehingga hubungan praktisnya adalah :

$$\Lambda_m = \frac{100 \times \frac{K}{(S \text{ cm}^{-1}) S} \text{ cm}^2 \text{ mol}^{-1}}{c/M} \quad (2)$$

Tabel 1. Mobilitas ion dalam air pada suhu 298 K

Ion	Mobilitas ionik ($10^{-8}\text{m}^2\text{s}^{-1}\text{V}^{-1}$)
K ⁺	7,62
Na ⁺	5,19
Cl ⁻	7,91
NO ₃ ⁻	7,40
F	5,70

Mobilitas ion dapat dihitung dengan pengukuran sebenarnya jarak yang ditempuh setiap ion dalam waktu tertentu dengan metode batas bergerak. makin besar mobilitas ion dalam larutan, maka makin besar pula kontribusinya pada konduktivitas (untuk muatan tertentu).

$$U = \frac{x}{t(\frac{dE}{dx})} \quad (3)$$

x = jarak (m)

t = waktu (dt)

$(\frac{dE}{dx})$ = kekuatan medan (volt.m⁻¹)

$$E = \frac{dE}{dx} = \frac{I}{AL_s} \quad (4)$$

$$\text{Maka } U = \frac{\lambda_m}{zF} \quad (5)$$

Z = valensi kation (130-132)

F = Faraday (133-135)

Sehingga

$$t_+ = \frac{U_+}{U_+ + U_-} \quad (6)$$

$$u = \frac{s}{E} \quad (7)$$

Jika larutan elektrolit kuat pada konsentrasi molar (c) menimbulkan ν_+ kation dengan muatan z_+

$$J(\text{ion}) = \frac{s\Delta t A \nu c N_A}{A\Delta t} = s\nu c N_A \quad (8)$$

setiap ion membawa muatan ze sehingga fluks muatan adalah :

$$J(\text{muatan}) = z s \nu c e N_A = z s \nu c F \quad (9)$$

Dengan $F = eN_A$ merupakan konstanta Faraday dan $s = uE$ maka fluksnya

$$J(\text{muatan}) = z u \nu c F E \quad (10)$$

Maka arus I : fluks muatan x luas

$$I = JA = z u v c F A E \quad (11)$$

Karena medan listrik merupakan gradien (136; 137) potensial $\Delta\phi/l$ maka :

$$I = \frac{z u v c F A \Delta\phi}{l} \text{ atau } I = \frac{\Delta\phi}{R} = \frac{L_s A \Delta\phi}{l} \quad (12)$$

Atau

$$L_s = z u v c F \quad (13)$$

Untuk larutan dalam limit (138-142) konsentrasi nol :

$$\Lambda_m^0 = (z_+ u_+ v_+ + z_- u_- v_-) F \quad (14)$$

untuk elektrolit simetris $z : z$ (misalnya CuSO_4) maka

$$\Lambda_m^0 = z(u_+ + u_-) F \quad (15)$$

Fraksi (143-147) dari arus total yang dibawa oleh ion jenis tertentu. Untuk larutan dengan 2 jenis ion, bilangan transport kation :

$$t_+ = \frac{I^+}{I} \quad (16)$$

I = arus total

$$I = t_+ + t_- \quad (17)$$

Bilangan transport pembatas (t^0) untuk limit konsentrasi nol dari larutan elektrolit.

Jika $I \propto \kappa$ sehingga :

$$t^0 = \frac{z v u}{\sum_i z v u_i} \quad (18)$$

Untuk elektrolit simetris (148-152) (bilangan muatan untuk kedua ion sama) maka persamaan diatas disederhanakan :

$$t^0 = \frac{u}{\sum_i u_i} \quad (19)$$

Hubungan antara konduktivitas ion dengan mobilitas ion :

$$t^0 = \frac{v \lambda}{\sum_i v_i \lambda_i} = \frac{v \lambda}{\Lambda_m^0} \quad (20)$$

Jadi untuk setiap jenis ion :

$$v \lambda = t^0 \Lambda_m^0 \quad (21)$$

Faktor-faktor yang mempengaruhi kecepatan ion :

- Berat dan muatan ion, semakin ringan ion tiap satuan muatan maka akan semakin cepat ion bergerak.
- Adanya hidrasi, semakin banyak molekul air yang mengerumuni ion maka akan semakin lambat gerakan ion.

- c. Orientasi atmosfer pelarut disekitar ion.
- d. Gaya tarik antara ion, semakin besar gaya tarik maka akan semakin lambat gerakan ion.
- e. Temperatur, semakin tinggi temperatur maka akan semakin cepat gerakan ion.
- f. Viskositas (153-156) , semakin besar viskositas maka akan semakin lambat gerakan ion.

c. Penentuan Bilangan Transport (55; 157-159)

Konsep dan pengukuran bilangan transportasi diperkenalkan oleh Johann Wilhelm Hittorf pada tahun 1853. Liquid Junction Potential dapat muncul dari ion dalam larutan yang memiliki nomor pengangkutan ion yang berbeda. Nomor angkut ion, juga disebut nomor transferensi, adalah fraksi dari total arus listrik yang dibawa dalam elektrolit oleh spesies ionik yang diberikan.

Perbedaan dalam bilangan transport ini timbul dari perbedaan dalam mobilitas listrik. Misalnya, dalam larutan natrium klorida, kurang dari setengah arus dibawa oleh ion natrium bermuatan positif (kation) (68; 160-163) dan lebih dari separuh dibawa oleh ion klorida bermuatan negatif (anion) (99; 164-166) karena ion klorida mampu bergerak lebih cepat, hal itu di karena ion klorida memiliki mobilitas yang lebih tinggi daripada ion natrium. Jumlah dari angka transport untuk semua ion dalam larutan selalu sama dengan kesatuan.

- a) Metode Hittorf
- b) Metoda perbatasan bergerak

1. Metode Hittorf

Prinsip yang di gunakan dengan menentukan perubahan konsentrasi elektrolit disekitar elektroda yang disebabkan karena migrasi ion. Sel Hittorf ialah seperangkat alat elektrolisis (97; 98; 167-169) yang terdiri atas pesawat Hittorf, sepasang elektroda, dan sumber tegangan arus searah.

Contoh :

Larutan AgNO_3 ditempatkan pada sel hittorf yang dilengkapi dengan 2 buah elektroda perak yang terbagi dalam 3 bagian :

- ruang anoda
- ruang tengah
- ruang katoda

Jika arus listrik lewat dalam larutan, maka ion Ag^+ akan bermigrasi ke arah katoda dan ion NO_3^- akan bermigrasi ke arah anoda.

Pada ruang katoda :

Andaikan arus yang lewat = Q coulomb = Q/F faraday

sebelum arus lewat jumlah ion $\text{Ag}^+ = n_0^k$ ekivalen

sesudah arus lewat jumlah ion $\text{Ag}^+ = n^k$ ekivalen

Jumlah ion Ag^+ yang bermigrasi masuk = $t_+ Q/F$ ekivalen (170-173)

Jumlah ion NO_3^- yang bermigrasi keluar = $t_- Q/F$ ekivalen

Jumlah ion Ag^+ yang hilang karena reduksi = Q/F ekivalen maka

$$\begin{aligned} n^k &= n_0^k + t_+ Q/F - Q/F \\ &= n_0^k + (t_+ - 1)Q/F \end{aligned}$$

sehingga :

$$t_+ = \frac{n^k - n_0^k}{Q/F} + 1 \quad (22)$$

Persamaan diatas juga bisa diturunkan dari perubahan jumlah ion NO_3^-

$$\begin{aligned} n^k &= n_0^k - t_- Q/F \\ &= n_0^k + (1 - t_+)Q/F \end{aligned}$$

$$t_+ = \frac{n^k - n_0^k}{Q/F} + 1 \quad (23)$$

Dengan menganalisa larutan didalam ruangan ini sebelum dan sesudah arus lewat dapat diketahui n_0^k dan n^k , sedangkan Q ditentukan dari coulometer yang disusun seri dengan alat elektrolisa dalam rangkaian listrik.

Pada ruang Anoda :

$$n^a = n_0^a - t_+ Q/F + Q/F \quad (24)$$

$$n^a = n_0^a - (t_+ - 1)Q/F \quad (25)$$

$$t_+ = \frac{n_0^a - n^a}{Q/F} + 1 \quad (26)$$

Analisa larutan (246-250) dari ruang tengah untuk kontrol karena jumlah ekivalen elektrolit didalam ruang ini tidak berubah karena jumlah yang masuk dan keluar sama besar. Jika hasil analisa menunjukkan adanya perubahan, maka berarti bahwa telah terjadi difusi dari ruang (251-252) anoda dan atau dari ruang katoda, maka percobaan harus di ulang dengan waktu pelewatan arus yang lebih singkat.

2. Metode Batas Bergerak (Moving Boundary)

Prinsip yang di gunakan ialah pipa A berisi larutan HCl dengan konsentrasi C ekivalen/liter. Anoda terbuat dari logam kadmium (174-178). Jika arus dilewatkan dalam larutan kadmium akan larut dan menghasilkan ion-ion Cd^+ . Baik ion H^+ maupun ion Cd^{2+} bergerak ke arah katoda, dengan ion H^+ bergerak lebih cepat. Antara larutan HCl (179-182) dan larutan $CdCl_2$ terdapat perbatasan yang jelas, karena ion-ion Cd^{2+} tidak mendahului ion-ion H^+ dan juga tidak ketinggalan di belakangnya karena larutan harus selalu netral (183-186).

Andaikan perbatasan berpindah dari a ke b sejauh l cm jika Q coulomb lewat. Jumlah muatan listrik yang lewat adalah Q/F ekivalen dan dari jumlah ini Q/F. t_+ ekivalen dihantarkan oleh ion-ion H^+ . Konsentrasi ion H^+ dalam larutan c ekivalen/liter atau c/1000 ekivalen/cc. Volum larutan yang

dilampaui oleh perbatasan $\frac{t_+ Q}{F} \cdot \frac{1000}{c}$. Jika luas penampang pipa ialah A cm^2 ;

$$lA = \frac{t_+ Q}{F} \cdot \frac{1000}{c} \quad (27)$$

d. Kecepatan hanyut

jika dua elektroda yang terpisah dengan jarak l berada pada selisih potensial $\Delta\phi$, maka ion dalam larutan di antara kedua elektroda itu akan mengalami medan listrik seragam yaitu:

$$E = \frac{\Delta\phi}{l} \quad (28)$$

Dalam medan demikian, ion yang bermuatan ze mengalami gaya sebesar :

$$I_e = ze \quad (29)$$

$$E = \frac{ze \Delta\phi}{l} \quad (30)$$

Kation bereaksi dengan percepatan menuju elektroda negative dan anion bereaksi dengan percepatan (241-245) menuju elektroda positif. akan tetapi saat ion bergerak melalui pelarut, maka ion akan mengalami gaya gesekan sehingga memperlambat I_e yang sebanding dengan kecepatannya. Jika diasumsikan bahwa hukum Stokes (187-191) untuk bola radius a dan s berlaku pada skala mikroskopis, maka kita dapat menuliskan gaya perlambatan ini sebagai:

$$I_e = fs \quad (31)$$

$$f = 6\pi\eta a \quad (32)$$

Kedua gaya (237-240) itu bekerja dalam arah yang berlawanan, dan ion mencapai kecepatan akhir yaitu kecepatan hanyut, jika gaya mempercepat I_e diimbangi oleh penahan kental I_e' maka gaya neto menjadi nol ($I_e = I_e'$) jika :

$$s = \frac{zeE}{f} \quad (33)$$

karena kecepatan hanyut mengatur laju transportasi ion, maka dapat diharapkan konduktivitas akan berkurang dengan bertambahnya viskositas pelarut (192-196) akan ukuran ion. contohnya, konduktivitas molar ion logam (231-235) alkali bertambah dari Li^+ ke Cs^+ , walaupun radius ionnya bertambah. paradoks ini terpecahkan jika kita menyadari bahwa radius a dalam rumus Stokes adalah radius hidrodinamik ion, yaitu radius efektifnya dalam larutan dengan memperhitungkan molekul H_2O yang dibawa dalam bola hidrasinya (226-230) ion kecil menimbulkan medan listrik lebih kuat dari pada ion besar sehingga ion kecil lebih terlarut secara ekstensif dari ion besar. jadi, ion dengan radius kecil dapat mempunyai radius hidrodinamik besar, karena ion itu menyeret banyak molekul pelarut melalui larutan itu saat bermigrasi.

Proton walaupun sangat kecil mempunyai konduktivitas molar yang sangat tinggi proton bertingkah laku dengan mekanisme yang tidak bersangkutan dengan gerakan sebenarnya melalui larutan. menurut mekanisme rantai migrasi proton proton yang terlarut bukan proton tunggal, bergerak melalui larutan dengan gerakan efektif (221-225) yang bersangkutan dengan penataan ulang ikatan dalam gugusan molekul air. Konduktivitas diatur oleh laju rotasi molekul air ke dalam orientasi yang dapat menerima dan mendonorkan proton, dan laju penerobosan proton dari satu ujung ikatan hydrogen ke ujung lainnya.

Pemisalan jika potensial CsCl adalah 1,0 V dan jarak antara elektroda adalah 4 cm

$$E = \frac{\Delta\phi}{t}$$

$$E = \frac{1}{4} = 0,25, \text{ maka kecepatan hanyut CsCl sebesar } 0,25 \text{ V/cm}$$

e. Hubungan Termodinamika

Hukum pertama Fick tentang difusi

Andaikan fluks partikel yang berdifusi merupakan gerakan sebagai reaksi terhadap gaya termodinamika yang timbul dari gradient konsentrasi. Partikel akan mencapai kecepatan hanyut tetap s jika gaya termodinamika f sama dengan tahanan kental (216-220). kecepatan hanyut ini akan sebanding dengan gaya termodinamika, dan dapat kita tuliskan $s \propto f$. Akan tetapi, fluks partikel J sebanding dengan kecepatan hanyut, dan gaya termodinamika sebanding dengan gradient konsentrasi dc/dx . Rantai kesebandingan itu ($J \propto s$, $s \propto f$, dan $f \propto dc/dx$) menunjukkan bahwa:

$$J \propto \frac{dc}{dx} \quad (34)$$

Yang merupakan kandungan hukum Fick

Hubungan Einstein

Hukum Fick untuk fluks partikel dalam mol molekul per satuan luas per satuan waktu adalah:

$$J = -D \frac{dc}{dx} \quad (35)$$

Dengan D merupakan koefisien difusi dan dc/dx merupakan kemiringan dari konsentrasi (211-215) molar. Adapun hubungan Fluks partikel dengan kecepatan hanyut :

$$J = sc \quad (36)$$

Hubungan ini merupakan kelanjutan dari argument yang sudah kita gunakan beberapa kali sebelumnya. Jadi, semua partikel dalam jarak $s\Delta t$, A , dapat melewati jendela dengan luas A dalam selang waktu Δt . Dengan demikian, jumlah mol (206-210) dapat lewat dalam selang waktu itu adalah: $s\Delta t \times c$, sehingga:

$$Sc = -D \frac{dc}{dx} \quad (37)$$

Jika sekarang kita menyatakan dc/dx dalam f , menggunakan persamaan 15, maka kita memperoleh:

$$S = -\frac{D}{c} \frac{dc}{dx} = \frac{D}{RT} \times f \quad (38)$$

Terdapat satu kasus ketika kita sudah mengetahui kecepatan hanyut dan gaya efektif yang bekerja pada partikel ialah ion dalam larutan (201-205) mempunyai kecepatan hanyut $s = \mu E$ jika ion itu mengalami gaya zeE , dan zFE per mol, dari medan listrik dengan kuat medan E . Jadi penggantian nilai tersebut ke dalam persamaan di atas, menghasilkan:

$$\mu E = \frac{D}{RT} \times zFE \quad (39)$$

atau

$$\mu = \frac{zFD}{RT} \quad (40)$$

Persamaan ini tertata ulang menjadi hasil yang sangat penting, yang dikenal sebagai **hubungan Einstein**, antara koefisien difusi dengan mobilitas ion:

$$D = \frac{\mu RT}{zF} \quad (41)$$

f. Viskositas

Viskositas merupakan suatu pengukuran dari ketahanan atau kekentalan fluida (197-200) yang diubah baik dengan tekanan maupun tegangan. Pada masalah sehari-hari (dan hanya untuk fluida), viskositas adalah "Ketebalan" atau "pergesekan internal".

Rumus untuk mencari viskositas gas adalah;

$$\mu(\text{cP}) = K \left(\frac{t(0C) + 273}{10.000} \right)^c \quad (42)$$

viskositas kinematik didapatkan melalui perbandingan viskositas absolut dengan kerapatan :

$$\text{viskositas kinematik} = \frac{\text{viskositas absolut}}{\text{kerapatan}}$$

CsCl memiliki viskositas yang rendah sehingga dapat digunakan dalam sentrifugasi DNA. dalam dunia kimia fisika, ada beberapa prinsip penetapan viskositas yaitu :

1. Viskosimeter kapiler (contoh : viskometer Ostwald)

Pada metode ini viskositas ditentukan dengan mengukur waktu yang dibutuhkan cairan uji untuk lewat antara dua tanda yaitu tanda awal dan akhir ketika ia mengalir karena gravitasi , melalui suatu tabung kapiler vertikal. Waktu alir dari cairan yang diuji dibandingkan dengan waktu yang dibutuhkan bagi suatu cairan yang viskositasnya sudah diketahui (biasanya air) untuk lewat antara dua tanda tersebut. Jika h_1 dan h_2 masing-masing adalah viskositas dari cairan yang tidak diketahui dan cairan standar , ρ_1 dan ρ_2 adalah kerapatan dari masing-masing cairan, t_1 dan t_2 adalah waktu alir dalam detik. Maka viskositas cairan yang tidak diketahui adalah :

$$\frac{h_1}{h_2} = \frac{\rho_1 \cdot t_1}{\rho_2 \cdot t_2} \quad (43)$$

$$\eta_1 = \frac{\rho_1 \cdot t_1 \cdot h_2}{\rho_2 \cdot t_2} \quad (44)$$

η_2 dan ρ_2 dapat diketahui dari literatur, ρ_1 kita diperoleh dari pengukuran kerapatan (berat jenis) dengan metode piknometer, t_1 dan t_2 masing-masing diketahui dengan cara mengukur waktu yang diperlukan oleh zat uji untuk mengalir melalui dua garis tanda pada tabung kapiler viskometer ostwald.

1. Viskometer bola jatuh (viskometer Hoespler)

Pada viskometer tipe ini, suatu bola besi jatuh ke bawah dalam suatu tabung gelas yang hampir vertikal, yang mengandung cairan yang diuji pada temperatur konstan. Laju jatuhnya bola yang mempunyai kerapatan dan diameter tertentu adalah kebalikan fungsi viskositas sample tersebut. Waktu bagi bola tersebut untuk jatuh antara dua tanda diukur dengan teliti dan diulangi beberapa kali. Viskositas cairan dihitung dengan rumus :

$$f = 6 \pi \eta r T \quad (45)$$

dimana f : gaya tahan

η : viskositas

r : jari-jari bola

v : kecepatan

Pada kesetimbangan gaya ke bawah $(m - m_0)g = f$, sehingga

$$6 \pi \eta r v = (m - m_0) g \quad (46)$$

Dengan

m : masa bola logam

m_0 : massa cairan yang dipindahkan oleh bola logam

g : konstanta

Kesimpulan

Senyawa sesium klorida merupakan senyawa ionik namun tidak sepenuhnya ionik karena elektronegativitas Cs sangat kecil. Konduktivitas CsCl termasuk rendah dan dapat larut dalam air. CsCl berupa padatan berwarna putih dan larut dalam air serta larut dalam etanol. Massa molar : 168.36 g/mol Penampilan: padat putih Densitas: 3.988 g/cm³ Titik didih: 1;297 °C (2;367 °F; 1;570 K) Kelarutan dalam air: 1910 g/L (25 °C), kecepatan hanyut CsCl sebesar 0,25 V/cm. CsCl memiliki kristal kubus sederhana dan dapat membentuk kisi kristal.

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