Analisis Termodinamika Molekul Magnesium Sulphate (MgSO₄)

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Abstrak. Magnesium sulfat merupakan salah satu garam anorganik dengan rumus kimia MgSO₄. Magnesium sulfat ini termasuk senyawa ionik karena terdapat ikatan antara logam magnesium dengan spesi non logam sulfat. Magnesium sulfat bersifat polar, bentuk anhidratnya sangat higroskopik dan mudah memiliki koordinasi dengan air. Umumnya magnesium sulfat terbentuk dalam formasi hidrat MgSO₄.xH₂O. Penelitian ini bertujuan untuk menganalisis pengaruh sifat termodinamika molekul MgSO₄ terhadap interaksi molekuler di dalam senyawa tersebut. Metode yang digunakan ialah pemodelan dengan aplikasi *ChemOffice 15.0*. Sedangkan untuk data mobilitas ion, konduktivitas, viskositas, kecepatan hanyut dengan menggunakan perhitungan dan data dari hasil review beberapa jurnal penelitian yang berkaitan dengan magnesium sulfat sesuai tahapan yang tertera pada *fishbond*. Magnesium sulfat memiliki sifat termokimia dalam fasa *solid* dengan ΔH_f , ΔG_f , S° , dan C_p pada tekanan 1 atm dan suhu 25°C yang masing-masing mempunyai nilai -1284,9 kJ/mol, -1170,7 kJ/mol, 91,6 J/molK dan 96,48 J/molK. Mobilitas ion Mg²⁺ dan SO₄²⁻ adalah 5,50.10⁻⁸m²s⁻¹V⁻¹ dan 8,29.10⁻⁸m²s⁻¹V⁻¹. Panas reaksi standar (ΔH_r°) MgSO₄ bernilai negatif maka reaksi bersifat eksotermis.

Keyword : *Magnesium sulfat, termodinamika, interaksi molekuler*

1. Pendahuluan

Magnesium sulfat merupakan garam tak berbau yang memiliki rasa asin yang pahit dan umumnya dijumpai sebagai kristal tak berwarna atau padatan kristalin putih. Senyawa ini sangat mudah larut dalam air panas. Magnesium sulfat ialah suatu garam anorganik yang mengandung unsur magnesium, sulfur dan oksigen, dengan rumus MgSO₄. Dalam molekul sulfat terdapat ikatan kovalen antara atom belerang (sulfur) dengan atom oksigen. Magnesium sulfat umumnya terbentuk dalam formasi hidrat MgSO₄.xH₂O dan tergolong senyawa ionik^(89; 90).

Di alam senyawa ini terdapat dalam bentuk mineral sulfat. Magnesium sulfat (MgSO₄) atau yang sering disebut dengan garam Inggris yang dapat dijumpai dalam bentuk magnesium sulfat heptahidrat (MgSO₄.7H₂O) merupakan salah satu produk industri. MgSO₄.7H₂O atau magnesium sulfat heptahidrat sering dinamakan dengan garam Epsom⁽⁹¹⁻⁹⁵⁾.

Magnesium sulfat memiliki nilai pH sekitar 6,0 (5,5 – 6,5) pada keadaan standar dan tekanan uap pada suhu 20°C < 0,01 mmHg⁽⁹⁶⁻⁹⁸⁾. Magnesium sulfat anhidrat (99-103) bersifat sangat higroskopik oleh karenanya senyawa magnesium sulfat biasa didapati dalam bentuk hidrat dengan struktur kristal monoklin. Magnesium sulfat anhidrat memiliki berat molekul 120,366 g/mol sedangkan pada magnesium sulfat heptahidrat memiliki berat molekul sebesar 246,47 g/mol. Densitas untuk magnesium sulfat anhidrat dengan

magnesium sulfat yang mengandung hidrat memiliki data yang berbeda. Densitas magnesium sulfat anhidrat ialah 2,66 gram/cm³, magnesium sulfat monohidrat sebesar 2,445 gram/cm³, magnesium sulfat heptahidrat 1,68 gram/cm³, magnesium sulfat 11-hidrat ialah 1,512 gram/cm³ ⁽¹⁰⁴⁻¹¹⁰⁾.

Begitu pula untuk nilai titik lebur magnesium sulfat, pada tekanan 1 atm magnesium sulfat anhidrat memiliki nilai titik lebur 1124 °C, untuk magnesium monohidrat nilai titik leburnya ialah 200 °C, magnesium sulfat heptahidrat nilai titik leburnya ialah 150 °C, dan magnesium undekahidrat ialah 20 °C ^(14; 56; 57; 111-113).

Magnesium sulfat ialah garam yang mudah larut dalam air panas. Kelarutan magnesium sulfat anhidrat dalam air bersuhu 0 °C ialah sebesar 26,9 gr/100 ml H₂O. Magnesium sulfat anhidrat juga dapat larut pada air bersuhu 20 °C sebesar 25,5 gr/100 ml H₂O. Sedangkan magnesium sulfat heptahidrat memiliki kelarutan sebesar 71 gr/100 ml H₂O pada suhu 20 °C ⁽¹¹⁴⁻¹¹⁸⁾.

Magnesium sulfat memiliki nilai konduktivitas ^(43; 68-71). Besarnya konduktivitas ditentukan oleh konsentrasi elektrolit. Pembawa muatan dapat berupa elektron seperti logam atau dapat juga digunakan ion positif dan ion negatif seperti dalam larutan elektrolit dan leburan garam. Arus listrik terjadi didalam suatu larutan karena adanya ion yang bergerak ⁽¹¹⁹⁻¹²²⁾.

Termokimia MgSO₄ dibagi atas dua bagian, yakni entropi molar standar dan entalpi molar standar ⁽⁵³⁻⁵⁵⁾. Termokimia magnesium sulfat dalam fasa *solid* dengan ΔH_f , ΔG_f , S° , dan C_p pada tekanan 1 atm dan suhu 25°C yang masing-masing mempunyai nilai -1284,9 kJ/mol, -1170,7 kJ/mol, 91,6 J/molK dan 96,48 J/molK. Panas reaksi standar (ΔH_r°) MgSO₄ bernilai negatif maka reaksi bersifat eksotermis ⁽¹²³⁻¹²⁵⁾.

Magnesium sulfat secara komersial umumnya digunakan dalam dunia farmasi baik penggunaan secara eksternal maupun internal ⁽¹²⁶⁻¹²⁹⁾. Selain itu magnesium sulfat digunakan dalam bahan kosmetik karena secara parsial biasanya dapat digunakan sebagai pencegah kerutan sementara akibat peningkatan kekuatan ionnya ^(25-27; 130; 131). Penggunaan lainnya pada bidang pertanian, sintesis elektrolit, dan koagulan bahan ^(13; 14; 32; 33; 93; 98; 117; 132-139).

Penelitian ini bertujuan untuk menganalisis pengaruh sifat termodinamika molekul MgSO₄ sehingga diketahui bagaimana interaksi molekuler di dalam senyawa tersebut dengan menggunakan aplikasi *Chem Office 15.0* serta untuk mengetahui sifat fisika dan kimianya begitu juga dengan penggunaannya dalam kehidupan.

2. Metodologi

Penelitian kali ini menggunakan metode penggambaran molekul dengan aplikasi *ChemOffice 15.0*. Untuk analisis lanjut mengenai MgSO₄ dilakukan beberapa tahapan sesuai yang tertera pada *fishbond* dibawah ini.

Penelitian dilakukan dengan tahap, yakni (1) Analisis molekul MgSO₄ secara dua dimensi dengan menggunakan *ChemDraw 2D*, (2) Analisis molekul MgSO₄ secara tiga dimensi menggunakan *Chem3D*.

Pada bagian *Chem3D*, struktur MgSO₄ diubah menjadi bentuk 3 dimensi dan kemudian dianalisis, seperti :

1. Menghitung MM2 dari masing-masing molekul yang terdiri atas MM2 minimization, MM2 dynamics dan MM2 properties. Langkahnya dengan klik pada menu *calculation*, pilih MM2 minimization kemudian klik *minimize energy* lalu klik *run*. Dengan langkah yang sama dilakukan untuk menentukan *molecular dynamics dan compute properties*.
2. Analisis *surface* molekul, diantaranya *Surface Solvent Accesible* dengan tipe *solid*, *wire mesh* dan *tranculent*. Kemudian *Surface Connolly Molecular* dengan tipe *solid*, *wire mesh* dan *tranculent*.
3. Menghitung nilai MOPAC dari masing-masing molekul yang terdiri dari MOPAC minimization dan MOPAC *properties*. Caranya dengan pilih MOPAC, kemudian

- pilih MOPAC *minization* kemudian pilih *run*. Dengan cara yang sama untuk menentukan MOPAC *properties*.
- Analisis jarak antara masing-masing atom tiap-tiap, molekul dengan pilih bagian *structure*, kemudian pilih *measurement*.

Bagan 1. Fishbone MgSO_4

3. Pembahasan

3.1. Sifat Magnesium Sulfat ($MgSO_4$)

Magnesium sulfat adalah garam anorganik yang mengandung unsur magnesium, sulfur dan oksigen, dengan rumus $MgSO_4$. Magnesium sulfat termasuk senyawa ionik karena terjadi ikatan antara logam magnesium dengan spesi non logam sulfat. Magnesium sulfat bersifat polar, bentuk anhidratnya sangat higroskopik dan mudah memiliki koordinasi dengan air. Dalam molekul sulfat terdapat ikatan kovalen antara atom belerang (sulfur) dengan atom oksigen^(89; 90).

Gambar 1. Magnesium sulfat anhidrat⁽¹⁴⁰⁾

Gambar 2. Magnesium sulfat heptahidrat⁽¹⁴¹⁾

$MgSO_4$ umumnya dapat dijumpai dalam garam *epsomite* yakni $MgSO_4 \cdot 7H_2O$. Di alam senyawa ini terdapat dalam bentuk mineral sulfat. Magnesium sulfat ($MgSO_4$) atau yang sering disebut dengan garam Inggris yang dapat dijumpai dalam bentuk magnesium sulfat heptahidrat ($MgSO_4 \cdot 7H_2O$) merupakan salah satu produk industri⁽¹⁴¹⁻¹⁴⁶⁾.

Magnesium sulfat ialah padatan tak berbau yang umumnya dijumpai sebagai kristal tak berwarna atau padatan kristalin putih. Senyawa ini sangat mudah larut pada air panas. Sifat dari senyawa $MgSO_4$ ditunjukkan pada tabel berikut:

Tabel 1. Sifat Fisika dan Kimia Senyawa MgSO_4 ^(51; 107; 147-153)

Sifat Fisika dan Kimia	Data
Penampilan	Kristal padat putih
Bau	Tidak berbau
Rasa	Pahit, asin, dingin
Berat molekul (gr/mol)	120,366 (anhidrat); 246,47 (heptahidrat)
Indeks bias (n_D)	1,523 (monohidrat); 1,433 (heptahidrat)
Densitas / Massa jenis (gr/cm ³)	2,66 (anhidrat); 2,445 (monohidrat); 1,68 (heptahidrat); 1,512 (11-hidrat)
Titik leleh (1 atm)	1124 °C (Anhidrat); 200 °C (monohidrat); 150 °C (heptahidrat); 20 °C (undekahidrat);
Tekanan Uap (mmHg)	< 0,01 (20°C)
Kelarutan per 100 ml H ₂ O	26,9 gr (0 °C); 25,5 gr anhidrat (20 °C); 71 gr heptahidrat (20 °C)
Nilai pH	Sekitar 6,0 (5,5 – 6,5)
Struktur kristal	monoklin (bentuk hidrat)

3.2. Bentuk Molekul

Magnesium sulfat ialah senyawa yang terdiri dari atom Mg, S dan O. Magnesium termasuk golongan IIA yang mempunyai 2 elektron di kulit terluarnya dan Sulfur merupakan golongan VIA yang mempunyai 6 elektron di kulit terluarnya, serta Oksigen juga dari golongan VIA yang mempunyai 6 elektron di kulit terluarnya. Dalam molekul sulfat terdapat ikatan kovalen antara atom belerang (sulfur) dengan atom oksigen ^(11; 21; 98; 154; 155).

Gambar 3. Molekul MgSO_4 dalam 2 dimensi (Chemoffice 2D Version 15, Perkinelmer Informatic. Inc, 2015)

Gambar 4. Molekul MgSO_4 dalam 3 dimensi (Chemoffice 2D Version 15, Perkinelmer Informatic. Inc, 2015)

(a)

(b)

(c)

(d)

Gambar 5. Analisis 3D Surface NH_4OH . (a), (b), (c), dan (d) *Solvent Accessible* Molekul MgSO_4 Mode *Solid*, *Wire Mesh*, *Dots* dan *Translucent*. (e), (f), (g), dan (h) *Connolly Molecular* MgSO_4 Mode *Solid*, *Wire Mesh*, *Dots* dan *Translucent*. (Chemoffice 3D Version 15, Perkinelmer Informatic. Inc, 2015)

3.3. Sintesis *Magnesium Sulfat* ^(137; 156-162)

Macam-macam proses pembuatan magnesium sulfat mempunyai rangkaian proses yang relatif sederhana, teknologi proses yang dipakai dewasa ini memberikan dua alternatif proses, yaitu:

3.3.1. *Proses I (Reaksi Netralisasi)*

Magnesium oksida direaksikan dengan H_2SO_4 di dalam reaktor pada kondisi operasi suhu 70°C dan tekanan 1 atm, maka terbentuk slurry MgSO_4 .

Slurry yang terbentuk diteruskan ke dalam filter untuk menghilangkan impuritas sebelum dimasukkan ke dalam evaporator untuk dipekatkan dan di masukkan ke crystallizer untuk pembentukan kristal $\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$.

Berikut sifat dari bahan baku pada reaksi netralisasi ini:

3.3.2. *Magnesium Oksida*

Magnesium oksida memiliki bentuk bubuk berwarna putih dengan rumus molekul MgO .

Tabel 2. Sifat Fisika dan Kimia Senyawa MgO	
Sifat	Data
Berat molekul	40,304 kg/kmol
Indeks bias	1,736
Densitas	3,65 g/cm ³
Titik leleh (1 atm)	300 °C
Titik didih (1 atm)	850 °C
Kelarutan per100 ml H ₂ O	0,0086 g

3.3.3. Asam Sulfat

Asam sulfat dengan rumus molekul H₂SO₄ berbentuk cair dan bersifat korosif terhadap semua jenis logam.

Tabel 3. Sifat Fisika dan Kimia Senyawa H ₂ SO ₄	
Sifat	Data
Berat molekul	98,07 kg/kmol
Densitas	1826,1 kg/m ³
Titik beku (1 atm)	10,5 °C
Titik didih (1 atm)	340

3.3.4. Proses II (Reaksi Penguraian)

Langbeinite (K₂SO₄.2MgSO₄) diuraikan menjadi MgSO₄.6H₂O. Proses ini menggunakan air panas suhu 50-60°C selama 6 jam. Larutan yang terbentuk kemudian dikristalkan pada suhu 20-35°C.

Dari beberapa faktor di atas dapat dilihat bahwa proses yang lebih mudah adalah proses 1, dengan pertimbangan: 1. Bahan baku yang digunakan lebih mudah dan murah untuk mendapatkannya. 2. Proses yang dijalankan lebih aman dan sederhana sehingga dapat menekan biaya pengadaan alat operasi dan pemeliharaannya lebih mudah.

3.4. Karakteristik Atom Penyusun dan Ion

3.4.1. Magnesium

Gambar 6. Logam Magnesium

H																	He						
Li	Be	12 Magnesium																B	C	N	O	F	Ne
Na	Mg																	Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr						
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe						
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn						
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt															
<<		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu								
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr								

Gambar 7. Magnesium Dalam Tabel Periodik

Magnesium ⁽¹⁶³⁻¹⁶⁷⁾ ialah salah satu unsur kimia yang memiliki lambang Mg dan nomor atom 12. Bentuknya berupa padatan berwarna abu-abu mengkilap. Magnesium memiliki tingkat oksidasi +2 dan magnesium terjadi secara alami hanya dalam kombinasi dengan unsur-unsur lain. Dalam bentuk unsur bebasnya logam magnesium sangat reaktif dan terbakar dengan cahaya berwarna putih cemerlang yang khas. Logam nya umumnya diperoleh dari proses elektrolisis garam magnesium yang diperoleh dari air garam. Magnesium bersifat kurang padat dibandingkan dengan aluminium, dan paduannya berharga karena kombinasi antara bobot yang ringan dan kekuatan ⁽¹⁶⁸⁻¹⁷¹⁾.

Magnesium esensial untuk semua sel dan sekitar 300 enzim memerlukan ion magnesium agar berfungsi. Ion magnesium ⁽¹⁷¹⁻¹⁷³⁾ berinteraksi dengan senyawa polifosfat seperti DNA, dan RNA. Senyawa magnesium digunakan secara medis sebagai obat dan untuk menstabilkan eksitasi saraf abnormal atau kejang pembuluh darah.

Magnesium memiliki beberapa sifat yaitu :

Tabel 4. Sifat Fisika dan Kimia Unsur Mg ⁽¹⁷⁴⁻¹⁷⁹⁾

Sifat Fisika dan Kimia	Data
Penampilan	Padatan berwarna abu-abu mengkilap
Bau	Tidak berbau
Massa atom (gr/mol)	24,305
Jari-jari atom	160 pm (1,13 Å)
Jari-jari kovalen	141±7 pm
Jari-jari Van der Waals	173 pm
Jari-jari ion	0,31 Å
Kepadatan (gr/cc ³)	1,738
Titik lebur	650°C
Titik didih	1090°C
Elektronegativitas	1,31 pauling
Potensial ionisasi	737,7 kJ/mol
Kalor peleburan	8,48 kJ/mol
Kalor Penguapan	128 kJ/mol
Kapasitas kalor molar	24,869 J/(mol·K)
Struktur kristal	Heksagon

3.4.2. Sulfur (Belerang)

Gambar 8. Padatan Belerang ⁽¹⁸⁰⁾

H																	He
Li	Be	16 Sulfur										B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt									
<<		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

Gambar 9. Sulfur Dalam Tabel Periodik

Belerang atau sulfur merupakan salah satu unsur kimia dalam tabel periodik yang bernomor atom 16 dan memiliki lambang S. Belerang merupakan unsur non logam yang tidak memiliki rasa. Belerang dalam bentuk aslinya berbentuk padatan kristalin kuning. Di alam bebas, belerang ditemukan sebagai unsur murni maupun sebagai mineral-mineral sulfida dan sulfat. Belerang adalah unsur yang ditemukan dalam dua buah asam amino. Contoh penggunaan belerang umumnya adalah dalam pupuk, bubuk mesiu, korek api, insektisida, dan fungisida ^(22; 76; 181-186).

Sulfur memiliki beberapa sifat yaitu :

Tabel 5. Sifat Fisika dan Kimia Unsur S ^(22; 24; 181; 186-190)

Sifat Fisika dan Kimia	Data
Penampilan	padatan kristalin kuning
Rasa	Tidak berasa
Massa atom (gr/mol)	32,065
Jari-jari atom	102 pm
Jari-jari kovalen	105±5 pm
Jari-jari Van der Waals	180 pm
Jari-jari Ion	0,29 Å (-6)
	1,84 Å (+2)
Kepadatan (gr/cc ³)	1,96
Titik lebur	115.21 °C
Titik didih	444.6°C

Elektronegativitas	2,58 pauling
Potensial ionisasi	999,6 kJ/mol
Kalor peleburan	(mono) 1.727 kJ/mol
Kalor Penguapan	(mono) 45 kJ/mol
Kapasitas kalor molar	22.75 J/(mol·K)
Struktur kristal	ortorombus

3.4.3. Oksigen

H																	He														
Li	Be	8 Oxygen																B	C	N	O	F	Ne								
Na	Mg																	Al	Si	P	S	Cl	Ar								
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr														
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe														
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn														
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt																							
																		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
																		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

<<

Gambar 10. Oksigen Dalam Tabel Periodik

Gambar 11. Gas Oksigen Dalam Tabung ⁽¹⁹¹⁾

Oksigen ialah salah satu unsur kimia dalam sistem tabel periodik yang bernomor atom 8 dan berlambang O. Oksigen mudah bereaksi dengan hampir semua unsur lainnya (terutama menjadi oksida). Pada keadaan standar, dua atom unsur oksigen berikatan menjadi senyawa dioksigen dengan rumus O_2 yang tidak berwarna, tidak berasa, dan tidak berbau ^(192; 193).

Umumnya kelompok molekul dalam makhluk hidup mengandung oksigen. Oksigen dalam bentuk O_2 dihasilkan dari air. Gas oksigen digunakan pada proses respirasi oleh hampir semua makhluk hidup ⁽¹⁹⁴⁻¹⁹⁶⁾.

Oksigen juga memiliki alotrop lainnya, yakni ozon (O_3). Lapisan ozon pada atmosfer membantu melindungi permukaan bumi dari radiasi ultraviolet ⁽¹⁹⁷⁻¹⁹⁹⁾.

Sulfur memiliki beberapa sifat yaitu :

Tabel 6. Sifat Fisika dan Kimia Unsur O (15; 181; 200-203)

Sifat Fisika dan Kimia	Data
Penampilan	gas
bau	Tidak berbau
Massa atom (gr/mol)	15,9994
Jari-jari atom	74 pm
Jari-jari kovalen	66±2 pm
Jari-jari Van der Waals	152 pm
Jari-jari ion	1,40 Å (-2)
Kepadatan (gr/cc)	1,15
Titik lebur	-218.35 °C
Titik didih	-182.95°C
Elektronegativitas	3,44 pauling
Potensial ionisasi	1313,9 kJ/mol
Kalor peleburan	(O ₂) 0.444 kJ/mol
Kalor Penguapan	(O ₂) 6.82 kJ/mol
Kapasitas kalor molar	(O ₂) 29.378 J/(mol·K)
Struktur kristal	kubus

3.4.4. Sulfat

Gambar 12. Anion Sulfat (Chemoffice 2D Version 15, Perkinelmer Informatic. Inc, 2015)

Ion sulfat merupakan anion poliatomik dengan rumus empiris SO_4^{2-} . Garam sulfat memiliki beragam aplikasi. Misalnya, magnesium sulfat (atau garam Epsom) digunakan dalam terapi mandi. Beberapa mikroorganisme yang hidup di dekat ventilasi termal laut dalam memanfaatkan sulfat sebagai akseptor elektron ⁽²⁰⁴⁻²⁰⁸⁾.

Ion sulfat (SO_4^{2-}) memiliki massa molekul 96,06 dalton. Setiap anion terdiri dari satu atom pusat sulfur yang dikelilingi oleh empat atom oksigen dalam susunan tetrahedral. Senyawa sulfat timbul ketika kation bergabung dengan anion SO_4^{2-} . Seringkali kombinasi senyawa sulfat menghasilkan senyawa ionik, meskipun sulfat dapat terlibat dalam ikatan kovalen dengan sebagian besar unsur. Banyak garam sulfat sangat larut dalam air. Pengecualian termasuk kalsium sulfat, strontium sulfat, dan barium sulfat, yang sulit larut ^(65; 209-211).

3.5. Karakteristik Ikatan Atom-atom pada Senyawa MgSO_4

Atom	Bond Atom	Bond Lenght	Angle Atom	First Angel	Third Atom	Second Atom	Angle Type
S[2]	-	-	-	-	-	-	-

O[3]	S[2]	1.428	-	-	-	-	-
O[4]	S[2]	1.428	O[3]	109.500	-	-	-
O[5]	S[2]	1.660	O[3]	109.500	O[4]	109.500	Pro S
O[6]	S[2]	1.660	O[3]	109.500	O[4]	109.500	Pro-R
Mg[1]	O[6]	4.000	S[2]	19.107	O[3]	-180.000	Dihedral

Tabel 7. Karakteristik Ikatan Atom-atom pada Senyawa MgSO_4

3.6. Optimasi MM2 Minimization Magnesium Sulfat

Proses pengolahan data MM2 dengan Chemoffice menunjukkan energi total molekul pada suhu target 300K adalah -260.8281 kcal/mol.

Hasil komputasinya sebagai berikut ;

Iteration	47	Steric Energy	-260.262	RMS Gradient	1.786	RMS Move	0.0034
Iteration	48	Steric Energy	-260.281	RMS Gradient	2.228	RMS Move	0.0010
Iteration	49	Steric Energy	-260.323	RMS Gradient	2.173	RMS Move	0.0027
Iteration	50	Steric Energy	-260.339	RMS Gradient	1.729	RMS Move	0.0014

Stretch:	0.5880
Bend:	148.6520
Stretch-Bend:	-0.8822
Torsion:	28.8011
Non-1,4 VDW:	80.1119
1,4 VDW:	-0.4174
Charge/Charge:	-568.4317
Charge/Dipole:	50.7502
Total Energy:	-260.8281 kcal/mol

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

Calculation ended

3.7. Optimasi MM2 Dynamics Magnesium Sulfat

MM2 Calculation completed successfully

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

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

Iteration	Time	Total Energy	Potential Energy	Temperature
1	0.002	-260.828 ± 0.000	-260.828 ± 0.000	0.00 ± 0.00
2	0.004	-260.758 ± 0.000	-260.782 ± 0.000	0.80 ± 0.00
3	0.006	-260.656 ± 0.000	-260.680 ± 0.000	0.81 ± 0.00
4	0.008	-260.464 ± 0.000	-260.527 ± 0.000	2.13 ± 0.00
5	0.010	-260.114 ± 0.000	-260.199 ± 0.000	2.87 ± 0.00
6	0.012	-259.793 ± 0.000	-259.969 ± 0.000	5.91 ± 0.00
7	0.014	-259.046 ± 0.000	-259.318 ± 0.000	9.11 ± 0.00
8	0.016	-258.901 ± 0.000	-259.277 ± 0.000	12.63 ± 0.00
9	0.018	-258.126 ± 0.000	-258.636 ± 0.000	17.11 ± 0.00
10	0.020	-258.524 ± 0.000	-259.123 ± 0.000	20.12 ± 0.00

Step sampai 50

Calculation ended

3.8. Optimasi MM2 Properties Magnesium Sulfat

-----MM2 Properties-----

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

Stretch: 1.0142
 Bend: 152.9931
 Stretch-Bend: -1.1163
 Torsion: 29.0142
 Non-1,4 VDW: 80.6804
 1,4 VDW: -0.2441
 Charge/Charge: -569.0403
 Charge/Dipole: 50.7909
 Total Energy: -255.9079 kcal/mol

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

cubic stretch: -2.0000
 quartic stretch: 2.3330
 p->dielec: 1.5000
 p->dieled: 1.5000

Bond Atoms	Length	R(0)	K(S)	Energy
S(2)-O(3)	1.439	1.4500	8.4120	0.0738
S(2)-O(4)	1.446	1.4500	8.4120	0.0109
S(2)-O(5)	1.678	1.6600	15.0000	0.3452
S(2)-O(6)	1.682	1.6600	15.0000	0.4824
O(3)-Lp(7)	0.617	0.6000	4.6000	0.0966
O(3)-Lp(8)	0.599	0.6000	4.6000	0.0004
O(4)-Lp(9)	0.596	0.6000	4.6000	0.0050
O(4)-Lp(10)	0.600	0.6000	4.6000	0.0000

Angle Atoms	Theta	Tzero	KB	EB	KSB	ESB
O(3)-S(2)-O(4)	129.246	116.6000	0.9000	3.1597	0.25	-0.1202
O(3)-S(2)-O(5)	111.652	109.5000	0.5000	0.0507	0.25	0.0098
O(3)-S(2)-O(6)	112.363	109.5000	0.5000	0.0898	0.25	0.0192
O(4)-S(2)-O(5)	109.655	109.5000	0.5000	0.0003	0.25	0.0014
O(4)-S(2)-O(6)	109.298	109.5000	0.5000	0.0004	0.25	-0.0022
O(5)-S(2)-O(6)	68.523	109.5000	0.5000	22.0287	0.25	-1.0242
S(2)-O(3)-Lp(7)	142.330	180.0000	0.5000	17.7397		
S(2)-O(3)-Lp(8)	143.304	180.0000	0.5000	16.6281		
Lp(7)-O(3)-Lp(8)	74.366	131.0000	0.2400	29.0174		
S(2)-O(4)-Lp(9)	136.036	180.0000	0.5000	26.7164		
S(2)-O(4)-Lp(10)	137.576	180.0000	0.5000	24.1914		
Lp(9)-O(4)-Lp(10)	86.387	131.0000	0.2400	13.3705		

Dihedral Atoms	Omega	V1	V2	V3	Et
O(4)-S(2)-O(3)-Lp(7)	-179.578	0.0000	10.0000	0.0000	0.0005
O(4)-S(2)-O(3)-Lp(8)	0.088	0.0000	10.0000	0.0000	0.0000
O(5)-S(2)-O(3)-Lp(7)	-37.245	0.0000	10.0000	0.0000	3.6630
O(5)-S(2)-O(3)-Lp(8)	142.421	0.0000	10.0000	0.0000	3.7193
O(6)-S(2)-O(3)-Lp(7)	37.528	0.0000	10.0000	0.0000	3.7107
O(6)-S(2)-O(3)-Lp(8)	-142.805	0.0000	10.0000	0.0000	3.6545
O(3)-S(2)-O(4)-Lp(9)	-179.472	0.0000	10.0000	0.0000	0.0008
O(3)-S(2)-O(4)-Lp(10)	0.215	0.0000	10.0000	0.0000	0.0001
O(5)-S(2)-O(4)-Lp(9)	37.620	0.0000	10.0000	0.0000	3.7261
O(5)-S(2)-O(4)-Lp(10)	-142.693	0.0000	10.0000	0.0000	3.6733

O(6)-S(2)-O(4)-Lp(9)	-35.711	0.0000	10.0000	0.0000	3.4069
O(6)-S(2)-O(4)-Lp(10)	143.977	0.0000	10.0000	0.0000	3.4588
Atoms	Charge1	Charge2	R	EC	
Mg(1)-O(5)	2.000	-1.000	1.5601	-283.796	
Mg(1)-O(6)	2.000	-1.000	1.5521	-285.245	

Atoms	Ion	Charge	Dipole	MU	R12(A)	ECD
Mg(1)-O(3)-S(2)	Mg(1)	2.000	O(3)-S(2)	2.930	3.0440	19.418
Mg(1)-O(4)-S(2)	Mg(1)	2.000	O(4)-S(2)	2.930	2.9549	17.296
Mg(1)-Lp(7)-O(3)	Mg(1)	2.000	Lp(7)-O(3)	0.900	3.6448	1.879
Mg(1)-Lp(8)-O(3)	Mg(1)	2.000	Lp(8)-O(3)	0.900	3.8632	5.552
Mg(1)-Lp(9)-O(4)	Mg(1)	2.000	Lp(9)-O(4)	0.900	3.4261	0.634
Mg(1)-Lp(10)-O(4)	Mg(1)	2.000	Lp(10)-O(4)	0.900	3.7117	6.011

The total energy for this frame: -255.908 kcal/mol

Calculation ended

Magnesium Sulfat (MgSO_4) ialah senyawa ion yang mempunyai ikatan ionik yang terbentuk dengan kecenderungan atom Mg melepas elektron dan molekul SO_4 menangkap electron agar tercapai konfigurasi gas mulia. Magnesium cenderung melepaskan elektron dan menjadi ion positif sedangkan kelompok atom sulfat, cenderung menangkap elektron dan menjadi ion negatif ^(11; 46-48; 212; 213).

Magnesium yang memiliki nomor atom 12, memiliki konfigurasi elektron (berdasarkan kulit atom) yaitu :

K	L	M
2	8	2

Untuk menuju stabil, magnesium melepaskan dua elektronnya. Sedangkan molekul sulfat memiliki dua elektron yang belum berpasangan yakni pada 2 atom O dengan struktur anionnya :

Gambar 13. Anion Sulfat

Untuk stabil, anion sulfat harus menangkap 2 elektron dari atom lain yakni pada senyawa ini adalah elektron dari kation magnesium.

Penggambaran ikatan ionik pada senyawa MgSO_4 seperti berikut

Gambar 14. Ikatan Ionik pada Senyawa MgSO_4

Molekul sulfat menangkap elektron yang dilepaskan oleh atom magnesium dan menjadi anion sulfat. Akibat perbedaan muatan ion magnesium dan ion sulfat menghasilkan terikat kuat atau gaya elektrostatis antara keduanya⁽²¹⁴⁾.

Gambar 15. Panjang masing-masing ikatan pada Senyawa MgSO_4

Pelarutan garam magnesium sulfat ke dalam air akan menyebabkan pemisahan ion. Hal ini disebabkan oleh adanya pengaruh kepolaran air terhadap gaya elektrostatis dalam senyawa ion sehingga ion dapat larut dalam air⁽²¹⁵⁾. Alasan inilah yang menyebabkan MgSO_4 hanya dapat larut dalam senyawa polar lainnya. Setelah dilarutkan, maka ion-ion akan bergerak dalam larutan. Ion akan dikelilingi oleh molekul air yang telah terprotonasi (H_3O^+)⁽²¹⁶⁾.

Gambar 16. Solvasi ion Magnesium

MgSO_4 merupakan salah satu senyawa yang terion dalam air dan termasuk elektrolit kuat. Ion-ion⁽²¹⁷⁾ dari senyawa ini akan bergerak didalam air dan dapat menghantarkan listrik jika dihubungkan dengan alat yang dapat mengubah energi kimia menjadi energi listrik. MgSO_4 ter-ion sempurna dalam air sehingga merupakan elektrolit kuat⁽²¹⁸⁾. Ada beberapa parameter yang menyebabkan ion dari MgSO_4 ini dapat menghantarkan listrik dan bagaimana gerakan ion ini.

3.9. Konduktivitas

Konduktivitas^(210; 219-221) adalah proses pergerakan ion akibat pengaruh medan listrik (E) . Karena adanya pergerakan ion tersebut, larutan dapat menghasilkan listrik.

Kemampuan suatu larutan dalam mengantarkan listrik disebut konduktivitas listrik. Arus listrik di hantarkan oleh ion ion yang terkandung didalam larutan sehingga konduktivitas listrik hanya memperhitungkan jumlah/konsentrasi ion pada larutan. Ion memiliki karakteristik tersendiri dalam menghantarkan arus listrik⁽²²²⁻²²⁵⁾. Maka dari itu nilai konduktivitas listrik hanya menunjukkan konsentrasi ion total dalam larutan. Banyaknya ion di dalam larutan juga dipengaruhi oleh padatan terlarut di dalamnya⁽²²⁶⁾.

Begitu pula dengan larutan magnesium sulfat juga memiliki nilai konduktivitas. Besarnya konduktivitas ini ditentukan oleh jumlah konsentrasi elektrolit. Energi listrik dapat ditransfer melalui materi berupa hantaran yang bermuatan listrik yang berwujud arus listrik yang berarti bahwa harus ada pembawa muatan listrik di dalam materi serta adanya gaya yang menggerakkan pembawa muatan tersebut⁽²²⁷⁻²³¹⁾. Pembawa muatan dapat berupa elektron atau dapat juga digunakan ion positif dan ion negatif dalam larutan elektrolit dan leburan garam⁽²³²⁾. Gaya listrik yang membuat muatan bergerak biasanya berasal dari sumber energi listrik. Arus listrik akan mengalir atau berpindah dari tempat yang berpotensi tinggi menuju tempat dengan potensial yang lebih rendah. Arus listrik terjadi didalam suatu larutan karena adanya ion-ion yang bergerak⁽²³³⁻²³⁵⁾.

Berikut data hasil percobaan konduktivitas yang dialami oleh larutan MgSO_4 :

Konsentrasi MgSO_4 dalam persen massa	Konduktivitas ($\text{mS} \cdot \text{cm}^{-1}$)
0,5 %	4,1
1 %	7,6
2 %	13,3
5 %	27,4
10 %	42,7
15 %	54,2

Tabel 8. Nilai Konduktivitas larutan MgSO_4 berdasarkan Konsentersasi Persen Massa

Tabel 9. Grafik konduktivitas terhadap konsentersasi MgSO_4

Dari tabel dan grafik diatas dapat disimpulkan bahwa semakin besar konsentrasi larutan magnesium sulfat maka konduktivitasnya juga semakin besar⁽²³⁶⁾.

Konduktivitas dapat dihitung dengan menggunakan rumus berikut⁽²³⁷⁻²⁴⁰⁾,

$$K = \frac{1}{\rho} (\Omega^{-1} \text{cm}^{-1}) \dots\dots\dots(1)$$

Konduktivitas biasanya tersedia dalam $S\text{ Cm}^{-1}$ dan konsentrasi dalam M. Sehingga hubungan praktisnya jika diketahui dalam mho/cm adalah :

$$R = \rho \times \frac{l}{A} \dots \dots \dots (2)$$

$$k = \frac{1}{RA} \dots \dots \dots (3)$$

$$\Lambda_m = \frac{100 \times \frac{K}{(S\text{ cm}^{-1})} \text{ cm}^2 \text{ mol}^{-1}}{c/M} \dots \dots \dots (4)$$

H₂O adalah penghantar buruk, $l\text{ H}_2\text{O} = 5 \times 10^{-8}$ mho/cm pada 25°C dan $\rho\text{ MgSO}_4 = 2.66\text{ g/cm}^3$ (anhidrat)

3.10. Mobilitas Ion

Mobilitas ion^(66; 67; 241) adalah kecepatan ion pada beda potensial antara kedua elektroda. Mobilitas ion merupakan perbandingan antara laju dan kuat medan.

$$\mu = \frac{v}{E} \dots \dots \dots (5)$$

Mobilitas ion juga dapat dihitung menggunakan pengukuran sebenarnya antara jarak yang ditempuh setiap ion dengan waktu yang diperlukannya untuk menempuh jarak

$$\mu = \frac{x}{\Delta t} \dots \dots \dots (6)$$

Mobilitas ion dapat dihitung dengan pengukuran sebenarnya jarak yang ditempuh setiap ion dalam waktu tertentu dengan metode batas bergerak⁽²⁴²⁾.

$$U = \frac{x}{t \left(\frac{dE}{dx} \right)} \dots \dots \dots (7)$$

x = jarak (m) t = waktu (dt) $\left(\frac{dE}{dx} \right)$ = kekuatan medan (volt.m^{-1})

$$E = \frac{dE}{dx} = \frac{I}{AL_s} \dots \dots \dots (8)$$

Maka

$$U = \frac{\lambda_m}{zF} \dots \dots \dots (9)$$

Z = valensi kation F = Faraday

Ion	Mobilitas Ionik ($10^{-8}\text{ m}^2\text{ s}^{-1}\text{ V}^{-1}$)
Mg ²⁺	5,50
SO ₄ ²⁻	8,29
K ⁺	7,62

Na ⁺	5,19
Cl ⁻	7,91
NO ₃ ⁻	7,40
F ⁻	5,70

Tabel 10. Mobilitas Ionik dalam air pada suhu 298 K

3.11. Kecepatan Hanyut

Untuk menahan partikel bermuatan agar kecepatan rata-rata tetap digunakan kecepatan hanyut. Kecepatan hanyut⁽²⁴³⁻²⁴⁷⁾ mempunyai arah sama dengan medan listrik dan hubungan keduanya dinyatakan dalam suatu konstanta yang disebut dengan mobilitas.

Gaya yang disebabkan oleh medan listrik.

$$F = Ze \cdot E \dots \dots \dots (10)$$

Jika dua elektroda yang terpisah dengan jarak l berada pada selisih potensial ($\Delta\phi$), maka ion dalam larutan diantara kedua elektroda tersebut, mengalami medan listrik (E) sebesar :

$$E = \frac{\Delta\phi}{l} \dots \dots \dots (11)$$

$$E = \frac{\text{selisih potensial}}{\text{dua elektroda yang terpisah dengan jarak}} \dots \dots \dots (12)$$

Maka

$$F = zeE = \frac{ze\Delta\phi}{l} \dots \dots \dots (13)$$

Gaya tersebut dipengaruhi juga oleh gaya Viskos (kekentalan) yang dirumuskan oleh persamaan Stokes:

$$F = 6 \pi \eta r v \dots \dots \dots (14)$$

Dimana: : viskositas

r : jari-jari

v : kecepatan

Ze : muatan masing-masing ion

Jika diabaikan efek penghambat lain, maka laju maksimum:

$$v = \frac{Ze \cdot E}{6 \pi \eta r} = \mu \cdot E \dots \dots \dots (15)$$

Dimana: : mobilitas ion (koefisien perbandingan antara laju dan kuat medan).

Sedangkan gaya perlambatan (F'), sedangkan gaya gesek (f) maka :

$$F' = fs \dots \dots \dots (16)$$

$$f = 6 \pi \eta a \dots \dots \dots (17)$$

Kedua gaya ini bekerja dalam arah yang berlawanan dan ion mencapai kecepatan akhir, yaitu kecepatan hanyut ion (s), jika gaya mempercepat F diimbangi oleh gaya perlambatan F' . Gaya neto menjadi nol ($F=F'$) jika :

$$s = \frac{zeE}{f} \dots\dots\dots(18)$$

Jika potensial MgSO_4 adalah 9,0 V dan jarak antar elektroda adalah 9 cm, maka kecepatan hanyutnya dapat dihitung dengan rumus

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

$$E = \frac{9}{9} = 1 \text{ V/cm}$$

3.12. *Bilangan transpor*

Fraaksi dari arus total yang dibawa oleh ion jenis tertentu. Untuk larutan dengan 2 jenis ion, bilangan transport kation :

$$t_+ = \frac{I^+}{I} \quad \quad \quad I = \text{ arus total}$$

$$I = t_+ + t_-$$

Bilangan transport pembatas^(162; 248; 249) (t^0) untuk limit konsentrasi nol dari larutan elektrolit.

Jika $I \propto K$ sehingga :

$$t^0 = \frac{zvu}{\sum_i zvu_i}$$

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

$$t^0 = \frac{u}{\sum_i u_i}$$

Hubungan antara konduktivitas ion dengan mobilitas ion :

$$t^0 = \frac{v\lambda}{\sum_i v_i \lambda_i} = \frac{v\lambda}{\Lambda_m^0}$$

Jadi untuk setiap jenis ion :

$$v\lambda = t^0 \Lambda_m^0$$

Penentuan Bilangan Transport :

1.1. Metode Hittorf

Prinsip : Menentukan perubahan konsentrasi elektrolit disekitar elektroda yang disebabkan karena migrasi ion.

1.2. Metoda perbatasan bergerak

Sel Hittorf : seperangkat alat elektrolisis yang terdiri atas pesawat Hittorf, sepasang elektroda, dan sumber tegangan arus searah

3.13. Hantaran Ion

Hantaran molar ion⁽²⁵⁰⁻²⁵³⁾ pada pengenceran tidak berhingga adalah :

$$v^+ \lambda^{0+} = (t_+)^0 \Lambda$$

$$v^- \lambda^{0-} = (t_-)^0 \Lambda$$

Dimana $(t_+)^0$ = bilangan transport ion sampai pengenceran tak hingga
 (v^+) = jumlah ion yang muatan positif

Tinjauan Termodinamika

Tinjauan secara termodinamika⁽²⁵⁴⁻²⁶⁰⁾ ialah untuk mengetahui sifat reaksi (eksotermis/endotermis). Untuk menentukan reaksi eksotermis atau endotermis, panas reaksi dapat dihitung dengan perhitungan panas pembentukan standar (ΔH_f° pada $P = 1$ atm dan $T = 25^\circ\text{C}$).

Komponen	ΔH_f° , Kkal/mol	ΔG_f° , Kkal/mol
MgO	-143,84	-143,73
H ₂ SO ₄	-193,69	-164,93
MgSO ₄	-304,94	-277,7
H ₂ O	-57,7979	-56,6899

Tabel 11. Harga ΔH_f° dan ΔG_f°

Panas reaksi standar (ΔH_r°)

$$\Delta H_r^\circ = \sum \Delta H_f^\circ \text{ produk} - \sum \Delta H_f^\circ \text{ reaktan}$$

$$\Delta H_r^\circ = (\Delta H_f^\circ \text{ MgSO}_4 + \Delta H_f^\circ \text{ H}_2\text{O}) - (\Delta H_f^\circ \text{ MgO} + \Delta H_f^\circ \text{ H}_2\text{SO}_4)$$

$$\Delta H_r^\circ = [(-304,94) + (-57,7979)] - [(-143,84) + (-193,69)]$$

$$\Delta H_r^\circ = -24,9879 \text{ Kkal/mol}$$

Karena ΔH_r° bernilai negatif maka reaksi bersifat eksotermis.

Kegunaan dari senyawa magnesium sulfat^(13; 132-137; 139; 261) dalam kehidupan sehari-hari. Anhidrat magnesium sulfat digunakan sebagai agen pengeringan. Karena bentuk anhidrat adalah higroskopis (mudah menyerap air dari udara). Magnesium sulfat dapat dimanfaatkan baik secara eksternal maupun internal. Magnesium sulfat oral digunakan untuk laksatif air asin atau purgatif osmotik. Magnesium sulfat merupakan sediaan utama magnesium intravena yakni melalui urat nadi.

Khasiat untuk penggunaan internal antara lain adalah ; Dalam bidang farmasi, diantaranya sebagai bahan Terapi untuk penyakit hipomagnesemia. Magnesium sulfat merupakan senyawa yang berperan sebagai agen antiaritmik dalam serangan jantung. Magnesium sulfat ini juga berperan sebagai bronkodilator setelah semua zat yang berperan sebagai beta-agonist dan antikolinergis telah dicoba sebelumnya. Senyawa magnesium sulfat dapat dinebulisasi untuk mengurangi gejala asma akut dan dapat dipakai dalam mengobati eklamsia pada wanita hamil. Senyawa ini ternyata juga dapat digunakan dalam menunda proses persalinan dengan jalan menghambat adanya kontraksi otot uterus pada kasus persalinan prematur. Magnesium sulfat intravena dimanfaatkan dalam mencegah *cerebral palsy* pada bayi prematur. Larutan garam sulfat seperti garam Epsom bisa diberikan sebagai bantuan pertama untuk keracunan barium klorida.

Pemanfaatan senyawa magnesium sulfat dalam pertanian, antara lain ; digunakan dalam memperbaiki kekurangan jumlah unsur magnesium atau belerang pada tanah, nyatanya magnesium ialah unsur penting di dalam molekul klorofil, dan sulfur sebagai makronutrien krusial lainnya. Larutan magnesium sulfat hampir mendekati pH netral, oleh karenanya penggunaannya tidak mengubah pH tanah secara berlebihan.

Senyawa magnesium sulfat anhidrat biasanya digunakan sebagai desiccant dalam proses sintesis senyawa organik. Hal tersebut dikarenakan oleh afinitas molekulnya yang kuat dengan air. Magnesium sulfat juga dapat digunakan sebagai garam mandi yakni dalam terapi flotasi dan efektif membuat tubuh terasa ringan. Secara tradisional, juga digunakan untuk menenangkan kaki yang terasa sakit.

Magnesium sulfat digunakan secara parsial dalam beberapa kosmetik, biasanya untuk mencegah kerutan kulit sementara akibat perendaman ekstremitas di dalam air murni karena kemampuannya dalam peningkatan kekuatan ion dan dapat terserap ke dalam kulit untuk mengurangi peradangan. Magnesium sulfat boleh juga digunakan sebagai koagulan dalam proses pembuatan tahu. Magnesium sulfat heptahidrat juga dimanfaatkan dalam mempertahankan jumlah konsentrasi ion magnesium dalam perairan. Pada akuarium laut magnesium dimanfaatkan untuk menstabilkan ion-ion dalam air laut dan menghalangi proses pengendapan.

Magnesium sulfat digunakan untuk membuat tembaga sulfat dan berperan sebagai elektrolit. Larutan magnesium sulfat dielektrolisis dengan anoda tembaga sehingga terbentuk senyawa tembaga sulfat, magnesium hidroksida, dan hidrogen:

4. Kesimpulan

Senyawa magnesium sulfat ialah senyawa suatu garam yang memiliki ikatan ion antara ion magnesium dengan ion sulfat dan di dalam molekul sulfat terdapat ikatan kovalen antara atom sulfur dan atom oksigen. Umumnya magnesium sulfat terbentuk dalam keadaan hidrat karena bentuk anhidratnya sangat higroskopis. Magnesium sulfat memiliki sifat termokimia dalam fasa *solid* dengan ΔH_f , ΔG_f , S° , dan C_p pada tekanan 1 atm dan suhu 25°C yang masing-masing mempunyai nilai -1284,9 kJ/mol, -1170,7 kJ/mol, 91,6 J/molK dan 96,48 J/molK. Konduktivitas dari senyawa MgSO_4 semakin meningkat seiring meningkatnya konsentrasi larutan elektrolit. Mobilitas ion Mg^{2+} dan SO_4^{2-} adalah $5,50 \cdot 10^{-8} \text{ m}^2 \text{ s}^{-1} \text{ V}^{-1}$ dan $8,29 \cdot 10^{-8} \text{ m}^2 \text{ s}^{-1} \text{ V}^{-1}$. Panas reaksi standar (ΔH_r°) MgSO_4 bernilai negatif maka reaksi bersifat eksotermis. Banyak bidang yang memanfaatkan senyawa magnesium sulfat, diantaranya bidang farmasi, pertanian, sintesis bahan, koagulan, kosmetik. Sedangkan magnesium sulfat anhidrat digunakan sebagai pengering karena sifat higroskopisnya.

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