

SOLUBILITY DATA SERIES

Volume 10

NITROGEN AND AIR

Volume Editor

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COMPONENTS:

- (1) Nitrogen; N₂; [7727-37-9]
 (2) Seawater

EVALUATOR:

Chen-Tung A. Chen
 School of Oceanography
 Oregon State University
 Corvallis, OR 97331
 U.S.A.
 February 1982

CRITICAL EVALUATION:

Nitrogen solubility measurements covering a wide range of salinity and temperature have been made by Törnøe (1), Dittmar (2), Hamberg (3), Fox (4), Rakestraw and Emmel (5), Benson and Parker (6), Douglas (7,8), and Murray, Riley and Wilson (9). The first three are only of historical interest because of the comparatively crude techniques used (9,10). The results of Fox (4) and Rakestraw (5) are more precise but apparently suffer from systematic errors (9). Benson and Parker (6) did not measure the nitrogen solubility directly but only reported the ratio of solubility of nitrogen to argon or oxygen. Because of these limitations, these three are cited here but are excluded from further analysis.

The first accurate nitrogen solubility measurements on water and seawater were carried out by Douglas (7, 8) and later confirmed by Murray, Riley and Wilson (9). Since the data of these workers are similar in precision and have been shown to agree well (9,11) their results were combined to form the data base for this study. The following equation is used to represent the Bunsen solubility coefficient with a standard deviation of 5.4×10^{-5} units (approximately 0.4%):

$$\ln C = 59.7745 - 76.7685/(T/100 \text{ K}) - 88.327 \ln (T/100 \text{ K}) \\ + 19.5287 (T/100 \text{ K}) + S \left[(7.1485 \times 10^{-3} - 3.9793 \times 10^{-2}/(T/100 \text{ K})) \right] \quad (1)$$

where T is the absolute temperature and S is the salinity in parts per thousand.

It should be pointed out that neither Douglas (7, 8) nor Murray, Riley and Wilson (9) corrected their data for the gas dissolution effect on the volume of the aqueous phase (11). Although their original experimental data have been compiled in this study, corrected values were used in the least squares fit. The corrections were made according to the following equation (Weiss, personal communication, 1979):

$$\Delta = \frac{273.15\phi_v}{22404 T} \quad (2)$$

In the present study, the partial molal volume of nitrogen (ϕ_v) in water is taken as $33.3 \text{ cm}^3/\text{mol}$ (12), and the volume of 1 mole of nitrogen is taken as 22404 ml at STP.

For practical oceanographic purposes, it is convenient to use an equation for the nitrogen solubilities from water-saturated air at 1 atm total pressure in ml(STP)/l as a function of salinity and temperature (11, 13, 14). In order to take full advantage of the precision of the data, it is also desirable to express the solubility unit in terms of $\mu\text{mol}/\text{kg}$, since it is pressure and temperature independent (11, 13, 14). Consequently, the combined data sets have also been fit to the following equations (15, 16):

$$\ln C (\text{ml}/\text{l}) = -29.1410 + 53.3161/(T/100 \text{ K}) + 7.499 \ln (T/100 \text{ K}) + \\ 1.8298 (T/100 \text{ K}) + S (7.365 \times 10^{-3} - \\ 4.038 \times 10^{-2}/(T/100 \text{ K})) \pm 0.4\% \quad (3)$$

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CRITICAL EVALUATION:

continued

$$\ln C \text{ (}\mu\text{mol/kg)} = -29.2710 + 58.6753/(T/100 \text{ K}) + 10.3401 \ln (T/100 \text{ K}) \\ + 1.5045 (T/100 \text{ K}) + S (7.116 \times 10^{-3} - \\ 4.186 \times 10^{-2}/(T/100 \text{ K})) \pm 0.4\% \quad (4)$$

The vapor pressures for pure water and seawater have been calculated using the formulas given by Besley and Bottomley (17, for pure water) and by Robinson (18, for seawater). The densities have been calculated using the equation of Millero, Gonzalez and Ward (19).

Limited information is available on the pressure effect of nitrogen solubility in ^{pure} water (12, 20-24), but nothing is available for seawater. It is the evaluator's opinion that, within the precision of these measurements, the pure water data can be applied to seawater. Since no seawater data are available, the more recent pure water data are compiled for reference but should be used for seawater only with caution.

References

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7. Douglas, E. *J. Phys. Chem.* 1964, 68, 169-74.
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continued

17. Besley, L.; Bottomley, G. A. *J. Chem. Thermodyn.* 1973, 5, 397-410.
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19. Millero, F. J.; Gonzalez, A.; Ward, G. K. *J. Mar. Res.* 1976, 34., 61-93.
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21. Frolich, P. K.; Tauch, E. J.; Hogan, J. J.; Peer, A. A. *Ind. Eng. Chem.*, 1931, 23 , 548-50.
22. Wiebe, R.; Gaddy, V. L.; Heins, C. Jr., *Ind. Eng. Chem.*, 1932, 24, 927.
23. Wiebe, R.; Gaddy, V. L.; Heins, C. Jr. *J. Am. Chem. Soc.* 1933, 55, 947-53.
24. Spink, T. J. M. S. thesis, Oregon State Univ., 1971.

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Water; H ₂ O; [7732-18-5]	ORIGINAL MEASUREMENTS: Frolich, P.K.; Tauch, E.J.; Hogan, J.J.; Peer, A.A. <i>Ind. Eng. Chem.</i> <u>1931</u> , 23, 548-50.												
VARIABLES: T/K = 298.15 P/MPa (absolute) = 0.1-19	PREPARED BY: C-T. A. Chen.												
EXPERIMENTAL VALUES: <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">P^a/atm</th> <th style="text-align: center;">S^b</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">20 (2.03 MPa)</td> <td style="text-align: center;">0.28</td> </tr> <tr> <td style="text-align: center;">60 (6.08 MPa)</td> <td style="text-align: center;">0.83</td> </tr> <tr> <td style="text-align: center;">100 (10.13 MPa)</td> <td style="text-align: center;">1.39</td> </tr> <tr> <td style="text-align: center;">140 (14.18 MPa)</td> <td style="text-align: center;">1.95</td> </tr> <tr> <td style="text-align: center;">190 (19.25 MPa)</td> <td style="text-align: center;">2.64</td> </tr> </tbody> </table> <p style="margin-left: 40px;">^a Absolute pressure.</p> <p style="margin-left: 40px;">^b Volume of nitrogen at 298.15K and 1 atm per volume of water; estimated from figure 3 of the original paper.</p>		P ^a /atm	S ^b	20 (2.03 MPa)	0.28	60 (6.08 MPa)	0.83	100 (10.13 MPa)	1.39	140 (14.18 MPa)	1.95	190 (19.25 MPa)	2.64
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METHOD/APPARATUS/PROCEDURE: Water was introduced into a steel cylinder of 2 liters capacity. Nitrogen was then forced in under pressure and the cylinder agitated in a water bath maintained at 298.15 K. After the pressure had become constant, some water was withdrawn. The water and the nitrogen separating from it on release of pressure were collected over mercury in a buret and the two volumes were read directly. Corrections were made for the vapor pressure of the liquid and the atmospheric solubility of the gas. Pressures were measured with a Bourdon Gauge.	SOURCE AND PURITY OF MATERIALS: <p style="text-align: center;">No details given</p> ESTIMATED ERROR: $\delta S/S = \pm 0.05$, compiler's estimate												
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METHOD/APPARATUS/PROCEDURE: Nitrogen was forced into a 61 cm long, 6.3 cm inside-diameter steel cylinder, which contained water saturated with nitrogen at room temperature and the desired pressure. The water was then transferred to a thermostated steel pipet where it was stirred at the desired temperature and pressure. After equilibrium, a sample was withdrawn into a weighed glass trap. The nitrogen released was then measured over mercury in a buret. The pressure was measured by a Bourdon gauge.	SOURCE AND PURITY OF MATERIALS: Compressed nitrogen from unspecified commercial source was drawn over heated copper wire at 450°C. Water and carbon dioxide were removed by passing nitrogen through soda lime.																																																
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METHOD/APPARATUS/PROCEDURE: Two cylinders of 1000 cc and 300 cc capacity, respectively were filled with water to three-fourth capacity. The nitrogen was bubbled through the larger and the smaller cylinder successively for several hours before water samples were taken from the smaller cylinder for analysis. The larger cylinder was used as a reservoir. The experiments were approached from both under and supersaturation.	SOURCE AND PURITY OF MATERIALS: (1) 99.9% pure. Impurities are argon and traces of oxygen.																																													
ESTIMATED ERROR: δT/K = ±0.05 δS/S = ±0.005, authors' estimate																																														
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VARIABLES: T/K = 298 P/MPa (hydrostatic) = 0-10		PREPARED BY: C-T.A. Chen.		
EXPERIMENTAL VALUES:				
P ^a /atm	P ^b /MPa	P ^c /mm Hg	P ^c /mm Hg	P ^c /mm Hg
T ^b /K = 298.15				
0	0	733	705	732
34	3.45	773	744	769
68	6.89	803	777	806.5
102	10.34	843	811	844
<p>^a Hydrostatic pressure.</p> <p>^b Calculated by compiler.</p> <p>^c The values in the table are the nitrogen equilibrium pressures in units of mm Hg. The table shows the effect of the hydrostatic pressure on the nitrogen equilibrium pressure.</p>				
AUXILIARY INFORMATION				
METHOD/APPARATUS/PROCEDURE: Water was gas-extracted before the experiment. Nitrogen at the desired initial pressure was dissolved in water at a constant temperature. The equilibrium vessel was shaken for 0.5 to 1 hr. After that, the water was transferred to a syringe which has a teflon tube attached to it. The pressure developed within the tube was then read on a mercury manometer.		SOURCE AND PURITY OF MATERIALS: No details given.		
		ESTIMATED ERROR:		
		REFERENCES:		

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Water; H ₂ O; [7732-18-5]	ORIGINAL MEASUREMENTS: Spink, T. J. M.S. Thesis, Oregon State University, Corvallis, OR, <u>1971</u> .																																																																
VARIABLES: T/K = 285-299 P/MPa (hydrostatic) = 0-0.20	PREPARED BY: C-T. A. Chen																																																																
EXPERIMENTAL VALUES: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">t/°C</th> <th style="text-align: left;">T^a/K</th> <th style="text-align: left;">P^b=0 (0 MPa)</th> <th style="text-align: left;">P=1 atm (0.1 MPa)</th> <th style="text-align: left;">P=2 atm (0.2 MPa)</th> <th style="text-align: left;">P=2 atm (0.2 MPa)</th> <th style="text-align: left;">P=2 atm (0.2 MPa)</th> <th style="text-align: left;">P=2 atm (0.2 MPa)</th> </tr> <tr> <th></th> <th></th> <th>10⁶ x₁</th> <th>10³ β^c</th> <th>10⁶ x₁</th> <th>10³ β^c</th> <th>10⁶ x₁</th> <th>10³ β^c</th> </tr> </thead> <tbody> <tr> <td colspan="8" style="text-align: center;">Mixed System</td> </tr> <tr> <td>12.3</td> <td>285.45</td> <td>18.78</td> <td>22.95</td> <td>33.88</td> <td>21.08</td> <td>56.30</td> <td>23.35</td> </tr> <tr> <td>19.6</td> <td>292.75</td> <td>18.08</td> <td>22.50</td> <td>34.27</td> <td>21.32</td> <td>53.32</td> <td>22.11</td> </tr> <tr> <td>25.5</td> <td>298.65</td> <td>15.96</td> <td>19.95</td> <td>33.01</td> <td>20.54</td> <td>48.60</td> <td>20.16</td> </tr> <tr> <td colspan="8" style="text-align: center;">Unmixed System</td> </tr> <tr> <td>25.5</td> <td>298.65</td> <td></td> <td>15.73</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p> ^a Calculated by compiler. ^b Hydrostatic pressure, in atm. ^c Bunsen coefficient. </p>		t/°C	T ^a /K	P ^b =0 (0 MPa)	P=1 atm (0.1 MPa)	P=2 atm (0.2 MPa)	P=2 atm (0.2 MPa)	P=2 atm (0.2 MPa)	P=2 atm (0.2 MPa)			10 ⁶ x ₁	10 ³ β ^c	10 ⁶ x ₁	10 ³ β ^c	10 ⁶ x ₁	10 ³ β ^c	Mixed System								12.3	285.45	18.78	22.95	33.88	21.08	56.30	23.35	19.6	292.75	18.08	22.50	34.27	21.32	53.32	22.11	25.5	298.65	15.96	19.95	33.01	20.54	48.60	20.16	Unmixed System								25.5	298.65		15.73				
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METHOD/APPARATUS/PROCEDURE: The saturation chamber was a six inch piece of Pyrex glass pipe, four inches in diameter. The nitrogen entered tangentially at the bottom and exited from the top where a manometer was connected for pressure measurement. Water samples were drawn after five days and the dissolved nitrogen concentration measured by a Varian Aerograph 2100 chromatograph. A different experiment was also performed where the gas entered the chamber from the top of the chamber and no mixing was allowed.	SOURCE AND PURITY OF MATERIALS: (1) Matheson pre-purified grade, >99.997% purity. (2) Doubly distilled.																																																																
ESTIMATED ERROR: $\delta x_1/x_1 = \pm 0.2$, compiler's estimate.																																																																	
REFERENCES:																																																																	

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Seawater	ORIGINAL MEASUREMENTS: Fox, C.J.J <i>Trans. Faraday Soc.</i> <u>1909</u> , 5, 68-87.
VARIABLES: T/K = 273-301 Chlorinity/‰ = 0-20	PREPARED BY: C-T.A. Chen

EXPERIMENTAL VALUES:					
T ^a /K	Chlorinity (%)	S ^b (cc/1000cc)	T ^a /K	Chlorinity (%)	S (cc/1000cc)
273.15	0	18.64	289.15	0	13.45
	4	17.77		4	12.94
	8	16.90		8	12.44
	12	16.03		12	11.93
	16	15.18		16	11.73
	20	14.31		20	10.92
277.15	0	17.02	293.15	0	12.59
	4	16.27		4	12.15
	8	15.51		8	11.70
	12	14.75		12	11.25
	16	14.00		16	10.81
	20	13.24		20	10.36
281.15	0	15.63	297.15	0	11.86
	4	14.98		4	11.46
	8	14.32		8	11.07
	12	13.66		12	10.67
	16	13.00		16	10.27
	20	12.34		20	9.87

continued on following page

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:

A modified form of Estreicher's (1) method. The seawater was acidified before boiling and weighing. The dry air was introduced from a burette to a glass bulb containing the gas-free seawater. The bulb was subsequently shaken and the resulting decrease of air in the burette measured until there were no changes.

SOURCE AND PURITY OF MATERIALS:

Unspecified air and seawater

ESTIMATED ERROR:

 $\delta S/S = \pm 0.004$, compiler's estimate

REFERENCES:

1. Estreicher, T.Z. *Physik. Chem.* 1899, 31, 176

COMPONENTS:

(1) Nitrogen; N₂; [7727-37-9]

(2) Seawater

ORIGINAL MEASUREMENTS:

Fox, C. J. J.

Trans. Faraday Soc. 1909, 5, 68-87.

EXPERIMENTAL VALUES:

continued

T ^a /K	Chlorinity (%)	S ^b (cc/1000cc)	T ^a /K	Chlorinity (%)	S (cc/1000cc)
	0	14.45		0	11.25
	4	13.88		4	10.89
285.15	8	13.30	301.15	8	10.52
	12	12.72		12	10.16
	16	12.15		16	9.80
	20	11.57		20	9.44

^a Original temperature reported in °C to 0.01°C.

^b Number of cc of nitrogen (containing Argon) absorbed by 1000cc of seawater from a free dry atmosphere at 760 mmHg total pressure.

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Seawater	ORIGINAL MEASUREMENTS: Rakestraw, N. W.; Emmel, V. M. <i>J. Phys. Chem.</i> <u>1938</u> , <i>42</i> , 1211-5.																																			
VARIABLES: T/K = 275-298 Chlorinity/‰ = 16-20	PREPARED BY: R. Battino																																			
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AUXILIARY INFORMATION																																				
METHOD/APPARATUS/PROCEDURE: Duplicate samples were saturated with air and then "analyzed for nitrogen" by a method unspecified.	SOURCE AND PURITY OF MATERIALS: (1) From air. (2) "Natura" seawater, diluted as needed.																																			
ESTIMATED ERROR: $\delta\alpha/\alpha = \pm 0.01$, compiler's estimate.																																				
REFERENCES:																																				

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Seawater Nitrogen/Argon and Nitrogen/Oxygen ratios.	ORIGINAL MEASUREMENTS: Benson, B.B.; Parker, P.D.M. <i>J. Phys. Chem.</i> <u>1961</u> , 65, 1489-96.
VARIABLES: T/K = 273 - 303 Concentration	PREPARED BY: R. Battino

EXPERIMENTAL VALUES:

Salinity/‰	t/°C	T ^a /K	N ₂ /Ar ^b	N ₂ /O ₂ ^b
0.066	0.0	273.2	37.92	1.836
0.066	5.0	278.2	38.29	1.825
0.48	10.0	283.2	38.42	1.826
0.066	15.0	288.2	38.66	1.859
0.084	20.0	293.2	39.03	1.887
0.11	25.0	298.2	39.43	1.941
0.102	30.0	303.2	39.71	1.987
32.59	0.0	273.2	37.78	1.833
32.565	5.0	278.2	37.78	1.803
32.60	10.0	283.2	38.00	1.830
32.65	15.0	288.2	37.51 ^c	1.821 ^c
32.58	20.0	293.2	38.47	1.907
32.65	25.0	298.2	38.78	1.934
32.97	30.0	303.2	39.25	1.954
34.70	0.0	273.2	37.52	1.845
34.70	5.0	278.2	37.64	1.816
34.71	10.0	283.2	38.05	1.828
34.67	15.0	288.2	37.96	1.833
34.695	20.0	293.2	38.28	1.858
34.65	25.0	298.2	38.89	1.947
35.11	30.0	303.2	39.23	1.926
36.12	0.0	273.2	37.74	1.860

continued on following page

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE: Four flasks containing distilled water and water of salinities ca. 32, 34, and 36‰ were thermostatted in contact with the atmosphere for over sixty hours. Samples were removed for salinity determinations. The dissolved gas was extracted from other samples and the Na/Ar and Na/O ₂ ratios were determined on a mass spectrometer tuned to be sensitive to the ratios. Details of the procedure are given in the paper.	SOURCE AND PURITY OF MATERIALS: (1) From air of compositions: 78.08% N ₂ ; 20.94% O ₂ , 0.93% Ar, 0.032% CO ₂ , traces of rare gases. (2) Distilled, sea water, or sea water diluted with distilled water.
	ESTIMATED ERROR: $\delta(N_2/Ar)/(N_2/Ar) = \pm 0.015$, authors' estimate. $\delta T/K = \pm 0.15$
	REFERENCES:

COMPONENTS:		ORIGINAL MEASUREMENTS:		
(1) Nitrogen; N ₂ ; [7727-37-9]		Benson, B.B.; Parker. P.D.M.		
(2) Seawater Nitrogen/Argon and Nitrogen/Oxygen ratios.		J. Phys. Chem. <u>1961</u> , 65, 1489-96.		
CRITICAL EVALUATION:		continued		
Salinity/‰	t/°C	T ^a /K	N ₂ /Ar ^b	N ₂ /O ₂ ^b
36.14	5.0	278.2	37.72	1.821
36.17	10.0	283.2	37.80	1.803
36.16	15.0	288.2	37.96	1.830
36.17	20.0	293.2	38.45	1.870
36.23	25.0	298.2	38.73	1.914
36.61	30.0	303.2	39.24	1.918
<p>a Calculated by compiler.</p> <p>b N₂/Ar and N₂/O₂ are the ratios of the concentrations of each species found in sea water saturated with air. To obtain the ratio of the Bunsen coefficients, α, use</p> $\alpha_{N_2/\alpha_{O_2}} = (20.94/78.08) (N_2/O_2) \text{ and}$ $\alpha_{N_2/\alpha_{Ar}} = (0.93/78.08) (N_2/Ar).$ <p>c This point rejected by the authors.</p> <p>d The authors give the following least squares smoothed equations:</p> <p>(1) N₂/O₂ = 1.800 + 0.00533 (t/°C) ± 1.3% for pure water.</p> <p>(2) N₂/O₂ = 1.807 + 0.00396 (t/°C) ± 1.5% for salinities of 34.5‰.</p> <p>(3) N₂/Ar = 37.90 + 0.0590 (t/°C) ± 0.2 to 1.5% for pure water.</p> <p>(4) N₂/Ar = 37.48 + 0.0522 (t/°C) ± 0.46% for salinities of 34.5‰.</p>				

COMPONENTS:

- (1) Nitrogen; N₂; [7727-37-9]
 (2) Seawater

ORIGINAL MEASUREMENTS:

Douglas, E.

J. Phys. Chem. 1965, 69, 2608-10.

EXPERIMENTAL VALUES:

continued

t/°C	T ^a /K	10 ² α ^c /cm ³ (STP)	cm ⁻³	atm ⁻¹
Cl‰ = 20.985				
2.10	275.25	1.689	1.692	1.698
5.92	279.07	1.566	1.563	1.567
10.15	283.30	1.442	1.436	1.442
15.05	288.20	1.319	1.320	1.320
19.41	292.56	1.227	1.222	1.231
24.88	298.03	1.140	1.139	1.139
29.99	303.14	1.076	1.078	1.071

^a Calculated by compiler.

^b Chlorinity is in grams of chlorine per kilogram of seawater.

^c Bunsen coefficient.

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Seawater		ORIGINAL MEASUREMENTS: Douglas, E. <i>J. Phys. Chem.</i> <u>1965</u> , <i>69</i> , 2608-10.		
VARIABLES: T/K = 275-303 Chlorinity/‰ = 15-21		PREPARED BY: R. Battino		
EXPERIMENTAL VALUES:				
t/°C	T ^a /K	10 ² α ^c /cm ³ (STP)	cm ⁻³	atm ⁻¹
Cl ‰ = 15.376				
1.50	274.65	1.857	1.858	1.852
6.46	279.61	1.661	1.667	1.670
10.00	283.15	1.544	1.550	1.551
14.81	287.96	1.416	1.422	1.417
19.99	293.14	1.299	1.303	1.304
25.08	298.23	1.209	1.210	1.203
29.83	302.98	1.137	1.144	1.139
Cl ‰ = 18.604				
2.17	275.32	1.746	1.748	1.746
6.80	279.95	1.588	1.589	1.592
10.25	283.40	1.485	1.476	1.485
14.51	287.66	1.373	1.367	1.370
19.41	292.56	1.264	1.269	1.268
25.27	298.42	1.161	1.168	1.165
29.72	302.87	1.109	1.111	1.107
continued on following page				
AUXILIARY INFORMATION				
METHOD APPARATUS/PROCEDURE: Used a modification of the Scholander microgasometric apparatus described in an earlier paper (1) of the author's. Gas-free seawater is equilibrated with the gas. All volumes are determined on a micro-meter buret. The apparatus takes about 8 cm ³ of seawater.		SOURCE AND PURITY OF MATERIALS: (1) Mass spectrometer analysis showed 0.04% O ₂ and less than 0.03% Ar. (2) Gas-free, millipore filtered, stored at 4°C.		
		ESTIMATED ERROR: δα/α = ±0.005, author's estimate δCl ‰ to ±0.05‰, author's estimate δT/K = ±0.01, compiler's estimate		
		REFERENCES: (1) Douglas, E. <i>J. Phys. Chem.</i> <u>1964</u> , <i>68</i> , 169-74.		

COMPONENTS: (1) Nitrogen; N ₂ ; [7727-37-9] (2) Seawater	ORIGINAL MEASUREMENTS: Murray, C.N.; Riley, J.P.; Wilson, T.R.S. Deep-Sea Research <u>1969</u> , 16, 297-310.
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VARIABLES: T/K = 274-304 Salinity/‰ = 0-40	PREPARED BY: R. Battino
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EXPERIMENTAL VALUES:					
Salinity /‰	Chlorinity /‰	10 ² α ^a	Salinity /‰	Chlorinity /‰	10 ² α ^a
0.58°C	(273.73 K)		6.87°C	(280.02 K)	
0.00	0.00	2.332	0.00	0.00	2.009
3.45	1.91	2.277	6.10	3.38	1.927
5.80	3.21	2.230	15.45	8.55	1.801
16.26	9.00	2.083	23.90	13.23	1.700
37.70	20.87	1.766	34.00	18.82	1.587
2.77°C	(275.92 K)		9.15°C	(282.30 K)	
0.00	0.00	2.217	0.00	0.00	1.913
8.65	4.79	2.078	10.01	5.45	1.784
18.80	10.41	1.938	13.55	7.50	1.739
26.42	14.62	1.837	20.73	11.48	1.663
33.20	18.38	1.731	31.15	17.24	1.546
4.95°C	(278.10 K)		11.08°C	(284.23 K)	
0.00	0.00	2.098	0.00	0.00	1.837
11.36	6.29	1.934	7.65	4.24	1.746
16.25	9.00	1.873	9.60	5.31	1.722
26.58	14.71	1.740	21.50	11.90	1.598
32.55	18.02	1.662	26.60	14.72	1.540
			34.25	18.96	1.456

continued on following page

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:

The Ben-Naim and Baer (1) apparatus was used. In this a vortex caused by high-speed stirring forces liquid up two side-arms to return via a central arm. Equilibrium is rapid. Gas uptake (in the wet state) is measured on a gas buret system. The paper contains drawings and a detailed description of the apparatus and procedure.

SOURCE AND PURITY OF MATERIALS:

- (1) British Oxygen Company, "white spot" grade, 99.9%
- (2) Surface seawater

ESTIMATED ERROR:

$$\begin{aligned}\delta T/K &= \pm 0.02 \\ \delta S\% &= \pm 0.02 \\ \delta \alpha/\alpha &= \pm 0.002\end{aligned}$$

REFERENCES:

1. Ben-Naim, A.; Baer, S. *Trans. Faraday Soc.* 1963, 59, 2735-8.

COMPONENTS:			ORIGINAL MEASUREMENTS:									
(1) Nitrogen; N ₂ ; [7727-37-9]			Murray; C.N.; Riley, J.P.;									
(2) Seawater			Wilson, T.R.S.									
Deep-Sea Research <u>1969</u> , 16, 297-310.												
EXPERIMENTAL VALUES:												
continued												
Salinity /‰	Chlorinity /‰	10 ² α ^a	Salinity /‰	Chlorinity ‰	10 ² α ^a							
14.88°C (288.03 K)			24.37°C (297.52 K)									
0.00	0.00	1.709	0.00	0.00	1.458							
8.35	4.62	1.604	14.15	7.83	1.329							
23.90	13.23	1.455	21.50	11.90	1.266							
26.75	14.81	1.424	31.85	17.63	1.189							
34.05	18.83	1.365	35.81	19.82	1.158							
20.18°C (293.33 K)			30.71°C (303.86 K)									
0.00	0.00	1.557	0.00	0.00	1.332							
9.94	5.50	1.451	11.65	6.45	1.242							
21.89	12.12	1.351	23.95	13.26	1.147							
23.52	13.02	1.335	35.20	19.49	1.074							
36.28	20.08	1.232	40.05	22.17	1.050							
<p>^a Bunsen coefficient, cm³ (STP) cm⁻³ atm⁻¹.</p> <p>The table below gives the authors' smoothed values of the Bunsen coefficient as a function of temperature and chlorinity.</p> <p style="text-align: center;">Chlorinity(‰)</p>												
T/K	t/°C	0	2	4	6	8	10	12	14	16	18	20
271.15	-1	---	---	---	---	---	---	---	---	---	---	19.00
272.15	-2	---	---	---	---	---	---	20.75	20.20	19.64	19.09	18.54
273.15	0	23.69	23.05	22.48	21.92	21.36	20.82	20.27	19.73	19.18	18.64	18.10
274.15	1	23.10	22.47	21.91	21.37	20.83	20.31	19.78	19.25	18.73	18.21	17.68
275.15	2	22.54	21.91	21.37	20.85	20.33	19.82	19.31	18.80	18.29	17.79	17.29
276.15	3	22.00	21.38	20.86	20.35	19.85	19.35	18.86	18.37	17.88	17.39	16.91
277.15	4	21.48	20.88	20.37	19.87	19.38	18.91	18.43	17.95	17.48	17.01	16.54
278.15	5	20.99	20.39	19.90	19.42	18.94	18.48	18.02	17.56	17.10	16.65	16.19
279.15	6	20.52	19.93	19.45	18.98	18.52	18.07	17.62	17.18	16.73	16.30	15.86
280.15	7	20.06	19.49	19.02	18.56	18.12	17.68	17.25	16.82	16.39	15.96	15.53
281.15	8	19.63	19.06	18.60	18.16	17.73	17.31	16.89	16.47	16.05	15.64	15.22
282.15	9	19.22	18.66	18.21	17.78	17.36	16.95	16.54	16.13	15.73	15.33	14.93
283.15	10	18.82	18.27	17.83	17.42	17.01	16.61	16.21	15.81	15.42	15.03	14.64
284.15	11	18.44	17.90	17.47	17.07	16.67	16.28	15.89	15.51	15.13	14.75	14.37
285.15	12	18.07	17.54	17.13	16.73	16.34	15.96	15.59	15.21	14.84	14.48	14.11
286.15	13	17.72	17.20	16.79	16.41	16.03	15.66	15.30	14.93	14.57	14.22	13.86
287.15	14	17.38	16.87	16.48	16.10	15.73	15.37	15.02	14.66	14.31	13.96	13.62
288.15	15	17.06	16.56	16.17	15.80	15.44	15.09	14.75	14.40	14.06	13.72	13.38
289.15	16	16.75	16.26	15.88	15.52	15.17	14.83	14.49	14.15	13.82	13.49	13.16
290.15	17	16.45	15.97	15.60	15.25	14.91	14.57	14.24	13.91	13.59	13.27	12.94
291.15	18	16.17	15.69	15.33	14.99	14.65	14.33	14.00	13.68	13.37	13.05	12.74
292.15	19	15.89	15.43	15.07	14.74	14.41	14.09	13.78	13.46	13.15	12.85	12.54
293.15	20	15.63	15.17	14.82	14.50	14.18	13.87	13.56	13.25	12.95	12.65	12.35
294.15	21	15.37	14.93	14.59	14.27	13.95	13.65	13.35	13.05	12.75	12.46	12.16
295.15	22	15.13	14.69	14.36	14.05	13.74	13.44	13.14	12.85	12.56	12.27	11.99
continued on following page												

COMPONENTS:		ORIGINAL MEASUREMENTS:										
(1) Nitrogen; N ₂ ; [7727-37-9]		Murray, C.N.; Riley, J.P.;										
(2) Seawater		Wilson, T.R.S.										
		Deep-Sea Research <u>1969</u> , 16, 297-310.										
EXPERIMENTAL VALUES:		continued										
T/K	t/°C	Chlorinity (‰)										
		0	2	4	6	8	10	12	14	16	18	20
296.15	23	14.90	14.47	14.14	13.83	13.53	13.24	12.95	12.66	12.38	12.10	11.82
297.15	24	14.67	14.25	13.93	13.63	13.33	13.05	12.76	12.48	12.20	11.93	11.65
298.15	25	14.46	14.04	13.73	13.43	13.14	12.86	12.58	12.31	12.04	11.77	11.50
299.15	26	14.25	13.84	13.54	13.25	12.96	12.69	12.41	12.14	11.87	11.61	11.34
300.15	27	14.05	13.65	13.35	13.06	12.79	12.52	12.25	11.98	11.72	11.46	11.20
301.15	28	13.85	13.47	13.17	12.89	12.62	12.35	12.09	11.83	11.57	11.31	11.06
302.15	29	13.67	13.29	13.00	12.72	12.46	12.19	11.94	11.68	11.42	11.17	10.92
303.15	30	13.49	13.12	12.83	12.56	12.30	12.04	11.79	11.54	11.29	11.04	10.79
304.15	31	13.32	12.96	12.68	12.41	12.15	11.90	11.65	11.40	11.15	10.91	10.67
305.15	32	13.16	12.80	12.52	12.26	12.01	11.76	11.51	11.27	11.03	10.79	10.55
306.15	33	13.00	12.65	12.38	12.12	11.87	11.63	11.38	11.14	10.90	10.67	10.43
307.15	34	12.85	12.50	12.24	11.99	11.74	11.50	11.26	11.02	10.78	10.55	10.32
The following table gives the authors' smoothed values of nitrogen solubility in units of cm ³ (STP)/Lm ³ from an atmosphere of 78.08% N ₂ and 100% relative humidity.												
T/K	t/°C	Chlorinity (‰)										
		0	2	4	6	8	10	12	14	16	18	20
271.15	-2	---	---	---	---	---	---	---	---	---	---	14.74
272.15	-1	---	---	---	---	---	---	16.13	15.69	15.26	14.82	14.39
273.15	0	18.39	17.89	17.45	17.01	16.58	16.16	15.73	15.31	14.89	14.47	14.05
274.15	1	17.92	17.43	17.00	16.58	16.16	15.76	15.35	14.93	14.53	14.13	13.72
275.15	2	17.48	16.99	16.57	16.17	15.76	15.37	14.97	14.58	14.18	13.79	13.41
276.15	3	17.05	16.57	16.17	15.77	15.38	15.00	14.62	14.24	13.86	13.48	13.11
277.15	4	16.64	16.17	15.78	15.39	15.01	14.65	14.28	13.90	13.54	13.18	12.81
278.15	5	16.25	15.78	15.41	15.03	14.66	14.31	13.95	13.59	13.24	12.89	12.53
279.15	6	15.88	15.42	15.05	14.68	14.33	13.98	13.63	13.29	12.94	12.61	12.27
280.15	7	15.51	15.07	14.71	14.35	14.01	13.67	13.34	13.00	12.67	12.34	12.01
281.15	8	15.17	14.73	14.37	14.03	13.70	13.37	13.05	12.72	12.40	12.08	11.76
282.15	9	14.84	14.41	14.06	13.73	13.40	13.09	12.77	12.45	12.14	11.84	11.53
283.15	10	14.52	14.09	13.75	13.44	13.12	12.81	12.50	12.20	11.90	11.59	11.29
284.15	11	14.21	13.80	13.47	13.16	12.85	12.55	12.25	11.95	11.66	11.37	11.08
285.15	12	13.91	13.51	13.19	12.88	12.58	12.29	12.01	11.71	11.43	11.15	10.87
286.15	13	13.63	13.23	12.92	12.62	12.33	12.05	11.77	11.49	11.21	10.94	10.66
287.15	14	13.36	12.97	12.67	12.37	12.09	11.81	11.54	11.27	11.00	10.73	10.47
288.15	15	13.10	12.71	12.41	12.13	11.85	11.59	11.32	11.06	10.79	10.53	10.27
289.15	16	12.84	12.47	12.18	11.90	11.63	11.37	11.11	10.85	10.60	10.35	10.09
290.15	17	12.60	12.23	11.95	11.68	11.42	11.16	10.91	10.65	10.41	10.16	9.91
291.15	18	12.37	12.00	11.73	11.47	11.21	10.96	10.71	10.46	10.23	9.98	9.75
292.15	19	12.14	11.79	11.51	11.26	11.01	10.76	10.53	10.28	10.05	9.82	9.58
293.15	20	11.92	11.57	11.31	11.06	10.82	10.58	10.34	10.11	9.88	9.65	9.42
294.15	21	11.71	11.37	11.11	10.87	10.63	10.40	10.17	9.94	9.71	9.49	9.26
295.15	22	11.51	11.17	10.92	10.69	10.45	10.22	9.99	9.77	9.55	9.33	9.12
296.15	23	11.31	10.99	10.74	10.50	10.27	10.05	9.83	9.61	9.40	9.19	8.97
297.15	24	11.12	10.80	10.56	10.33	10.10	9.90	9.67	9.46	9.25	9.04	8.83
298.15	25	10.94	10.62	10.39	10.16	9.94	9.73	9.52	9.31	9.11	8.90	8.70
299.15	26	10.76	10.45	10.22	10.00	9.78	9.58	9.37	9.17	8.96	8.77	8.56
300.15	27	10.59	10.28	10.06	9.84	9.64	9.43	9.23	9.03	8.83	8.63	8.44
continued on following page												

COMPONENTS:		ORIGINAL MEASUREMENTS:											
(1) Nitrogen; N ₂ ; [7727-37-9]		Murray, C.N.; Riley, J.P.; Wilson, T.R.S.											
(2) Seawater		<i>Deep-Sea Research</i> <u>1969</u> , 16, 297-310.											
EXPERIMENTAL VALUES:													
continued													
Chlorinity (‰)													
T/K	t/°C	0	2	4	6	8	10	12	14	16	18	20	
301.15	28	10.41	10.13	9.90	9.69	9.49	9.28	9.09	8.89	8.70	8.50	8.31	
302.15	29	10.25	9.97	9.75	9.54	9.35	9.14	8.96	8.76	8.57	8.38	8.19	
303.15	30	10.09	9.82	9.60	9.40	9.20	9.01	8.82	8.63	8.45	8.26	8.07	
304.15	31	9.94	9.67	9.46	9.26	9.07	8.88	8.69	8.51	8.32	8.14	7.96	
305.15	32	9.79	9.53	9.32	9.12	8.94	8.75	8.57	8.39	8.21	8.03	7.85	
306.15	33	9.65	9.39	9.19	8.99	8.81	8.63	8.45	8.27	8.09	7.92	7.74	
307.15	34	9.51	9.25	9.06	8.87	8.69	8.51	8.33	8.15	7.98	7.81	7.64	