

<p>COMPONENTS:</p> <ol style="list-style-type: none"> 1. Hydrogen selenide; H_2Se; [7783-07-5] 2. Aqueous and non-aqueous solvents. 	<p>EVALUATOR:</p> <p>Peter G.T. Fogg, Department of Applied Chemistry and Life Sciences, Polytechnic of North London, Holloway, London N7 8DB, U.K.</p> <p>July 1987</p>
<p>CRITICAL EVALUATION:</p> <p>Few measurements of the solubility of hydrogen selenide have been reported in the literature. At 298.15 K liquid hydrogen selenide has a lower vapor pressure than liquid hydrogen sulfide. Raoult's law leads one to expect that hydrogen selenide is likely to have a higher mole fraction solubility in a given solvent than hydrogen sulfide, at the same temperature and partial pressure of gas. This appears to be the case for eight of the nine non-aqueous solvents for which data is available. Hydrogen sulfide is, however, the more soluble in water under the conditions which have been investigated.</p> <p>Devyatykh <i>et al.</i> (1) measured distribution constants for certain non-aqueous solvents. These can only be equated with Ostwald coefficients if it can be established that surface effects made negligible contribution to the chromatographic process and that conditions were close to equilibrium. In the absence of other data these measurements are best considered as an indication of approximate relative solubilities in different solvents. The following solvents were studied:</p> <p>2-Ethoxyethanol; $C_4H_{10}O_2$; [110-80-5] 1,1'-Oxybis(2-chloroethane); Nitrobenzene; $C_6H_5NO_2$; [98-95-3] $C_4H_8Cl_2O$; [111-44-4] 2-Furancarboxaldehyde; $C_5H_4O_2$; [98-01-1] 1,2-Benzenedicarboxylic acid, didecyl ester; $C_{28}H_{46}O_4$; [84-77-5] Triethoxysilane; $C_6H_{16}O_3Si$; [998-30-1] Silicic acid, tetraethyl ester; Liquid paraffin $C_8H_{20}O_4Si$; [78-10-4]</p> <p>In all these solvents, with the exception of 1,2-benzenedicarboxylic acid, didecyl ester, hydrogen selenide has a higher distribution constant than hydrogen sulfide at 293.2 K.</p> <p>Solubility in water at a partial pressure of 1.013 bar has been reported by McAmis & Felsing (2) for 287.7 to 308.2 K and by Dubeau <i>et al.</i> (3) for 298.2 to 343.2 K. There is, on the whole, good agreement between the two sets of measurements (see fig.7). Mole fraction solubilities for a partial pressure of 1.013 bar may be fitted to the following equation:</p> $\ln x_{H_2Se} = 9.15 + 974/(T/K) - 3.542 \ln (T/K) + 0.00420 (T/K)$ $\delta x_{H_2Se} = \pm 2.3 \times 10^{-5}$ <p>This equation is valid in the temperature range 287.7 to 343.2 K.</p> <p>The value given by McAmis and Felsing for 308.2 K seems to be out of line with the data at higher temperatures by Dubeau and has not been used by the evaluator in the calculation of this smoothing equation.</p> <p>McAmis & Felsing also investigated the solubility at 298.15 K and a total pressure of 1.013 bar in solutions of hydrogen iodide of concentrations to 2.73 mol dm^{-3}. Solubilities increase with concentration of hydrogen iodide and follow a Sechenov relationship very closely. They may be fitted to the equation:</p> $\log_{10}(\text{concn. } H_2S/\text{mol } dm^{-3}) = -1.0788 + 0.04011 (\text{concn. HI/mol } dm^{-3})$ <p>Standard deviation of $\log_{10}(\text{concn. of } H_2S/\text{mol } dm^{-3}) = \pm 0.0035$</p> <p>These data for solutions of hydrogen iodide appear to be reliable and may be accepted on a tentative basis.</p> <p><u>References</u></p> <ol style="list-style-type: none"> 1. Devyatykh, G.G.; Ezheleva, A.E.; Zorin, A.D.; Zueva, M.V. <i>Zh. Neorgan. Khim.</i> <u>1963</u>, <i>8</i>, 1307-1313. <i>Russ. J. Inorg. Chem.</i> <u>1963</u>, <i>8</i>, 678-682. 2. McAmis, A.J.; Felsing, W.A. <i>J. Am. Chem. Soc.</i> <u>1925</u>, <i>4</i>, 2633-2637. 3. Dubeau, C.; Sisi, J.-C.; Ozanne, N. <i>J. Chem. Engng. Data</i> <u>1971</u>, <i>16</i>, 78-79. 	

COMPONENTS:

1. Hydrogen selenide; H₂Se;
[7783-07-5]
2. Aqueous and non-aqueous solvents

EVALUATOR:

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and Life Sciences,
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July 1987

CRITICAL EVALUATION:

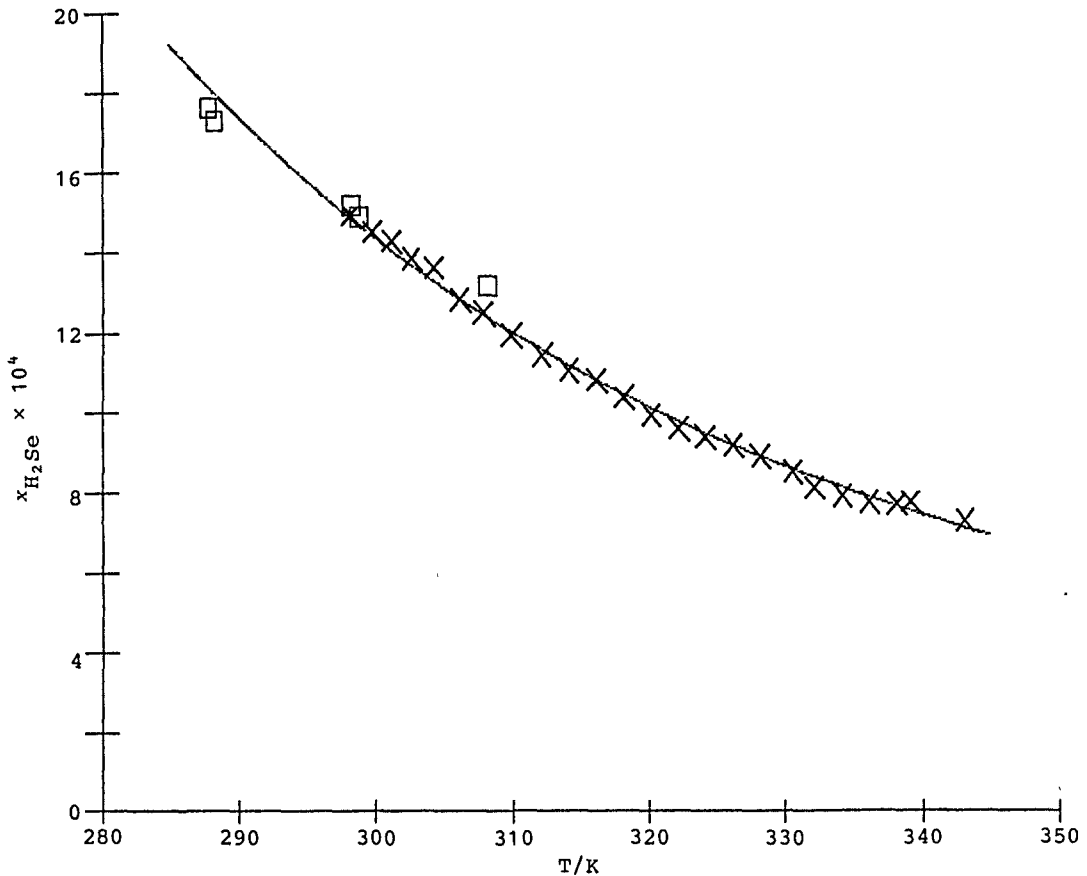


Fig. 7 Variation with temperature of the mole fraction solubility of hydrogen selenide in water at a partial pressure of 1.013 bar

Experimental points have been superimposed upon the curve corresponding to the equation:

$$\ln x_{H_2Se} = 9.15 + 974/(T/K) - 3.542 \ln (T/K) + 0.00420 (T/K)$$

□ McAmis & Felsing (2)

× Dubeau *et al.* (3)

COMPONENTS:		ORIGINAL MEASUREMENTS:	
1. Hydrogen selenide; H_2Se ; [7783-07-5] 2. Various liquids		Devyatykh, G. G.; Ezheleva, A. E.; Zorin, A. D.; Zueva, M. V. <i>Russ. J. Inorg. Chem.</i> 1963, 8, 678-682.	
VARIABLES:		PREPARED BY:	
Temperature, pressure		P. G. T. Fogg	
EXPERIMENTAL VALUES:			
Solvent	P_{H_2Se}/mmHg	Distribution constant $\text{vol}_{H_2Se}/\text{vol}_{\text{solvent}}$	Heat of solution $/\text{kcal mol}^{-1}$
2-Ethoxyethanol; $C_4H_{10}O_2$; [110-80-5]	0.3	14.42	- 1.6
1,1'-oxybis[2-chloroethane]; $C_4H_8Cl_2O$; [111-44-4]	0.2	12.5	- 3.4
Nitrobenzene; $C_6H_5NO_2$; [98-95-3]	0.2	22.0	- 2.45
Liquid paraffin	0.3	30.0	-
Temperature = 293.2 K. 760 mmHg = 1 atm = 1.013×10^5 Pa. Distribution constants were measured between 278.2 K and 323.2 K with a total pressure of hydrogen selenide and carrier gas of about 760 mmHg. At a fixed temperature the distribution constants did not depart from the mean values by more than $\pm 3\%$. These mean values were reported at one temperature only but heats of solution, said to have been calculated from the variation of distribution constants with temperature, were given. If it is assumed that distribution constants vary with temperature according to equations of the form: $\ln K = (-\Delta H/RT) + A$			
(cont.)			
AUXILIARY INFORMATION			
METHOD/APPARATUS/PROCEDURE:		SOURCE AND PURITY OF MATERIALS:	
A chromatographic method was used. Temperatures were controlled to ± 0.5 K. The support phase consisted of Nichrome spirals. The carrier gas was either nitrogen or hydrogen. The volume, V_l , of the liquid phase was calculated from the weight of the column before and after filling with liquid and allowing to drain. The free volume, V_g , was equated with the retention volume for hydrogen gas. The distribution constant, K , was calculated from the James and Martin equation: $V_R = V_g + KV_l$ where V_R is the retention volume for hydrogen selenide.		1. Prepared by hydrolysis of Al_2Se_3 ; purified by vacuum distillation; chromatographically pure. H_2 and N_2 : passed through activated carbon and through molecular sieve.	
		ESTIMATED ERROR:	
		REFERENCES:	

<p>COMPONENTS:</p> <p>1. Hydrogen selenide; H₂Se; [7783-07-5]</p> <p>2. Various liquids</p>	<p>ORIGINAL MEASUREMENTS:</p> <p>Devyatykh, G. G.; Ezheleva, A. E.; Zorin, A. D.; Zueva, M. V. <i>Russ. J. Inorg. Chem.</i> <u>1963, 8, 678-682.</u></p>												
<p>EXPERIMENTAL VALUES:</p> <p>where K is the distribution constant for a temperature T, ΔH is the heat of solution of hydrogen selenide in the solvent and A is a constant for the solvent, then distribution constants at any temperature in the range 278.2 K to 323.2 K may be estimated from a value at 293.2 K and the corresponding value of the heat of solution. The equation for K may be written in the form:</p> $K = \exp [A + (B/T)].$ <p>The following values of A and B have been calculated by the compiler:</p> <table border="1" data-bbox="113 733 1243 934"> <thead> <tr> <th>Solvent</th> <th>A</th> <th>B/K</th> </tr> </thead> <tbody> <tr> <td>2-Ethoxyethanol</td> <td>- 0.079</td> <td>806</td> </tr> <tr> <td>1,1'-oxybis[2-chloroethane]</td> <td>- 3.313</td> <td>1712</td> </tr> <tr> <td>Nitrobenzene</td> <td>- 1.116</td> <td>1234</td> </tr> </tbody> </table>		Solvent	A	B/K	2-Ethoxyethanol	- 0.079	806	1,1'-oxybis[2-chloroethane]	- 3.313	1712	Nitrobenzene	- 1.116	1234
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VARIABLES: Temperature	PREPARED BY: P. G. T. Fogg															
EXPERIMENTAL VALUES: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Solvent</th> <th style="text-align: center;">Distribution constant vol_{H_3P} /vol_{solvent}</th> <th style="text-align: center;">Heat of solution /kcal mol⁻¹</th> </tr> </thead> <tbody> <tr> <td>2-Furancarboxaldehyde; $C_5H_4O_2$; [98-01-1]</td> <td style="text-align: center;">22.5</td> <td style="text-align: center;">-</td> </tr> <tr> <td>1,2-Benzenedicarboxylic acid, didecyl ester; $C_{28}H_{46}O_4$; [84-77-5]</td> <td style="text-align: center;">28.5</td> <td style="text-align: center;">-</td> </tr> <tr> <td>Triethoxysilane; $C_6H_{16}O_3Si$; [998-30-1]</td> <td style="text-align: center;">5.21</td> <td style="text-align: center;">- 5.0</td> </tr> <tr> <td>Silicic acid, tetraethyl ester; $C_8H_{20}O_4Si$; [78-10-4]</td> <td style="text-align: center;">11.52</td> <td style="text-align: center;">- 5.4</td> </tr> </tbody> </table>		Solvent	Distribution constant vol_{H_3P} /vol _{solvent}	Heat of solution /kcal mol ⁻¹	2-Furancarboxaldehyde; $C_5H_4O_2$; [98-01-1]	22.5	-	1,2-Benzenedicarboxylic acid, didecyl ester; $C_{28}H_{46}O_4$; [84-77-5]	28.5	-	Triethoxysilane; $C_6H_{16}O_3Si$; [998-30-1]	5.21	- 5.0	Silicic acid, tetraethyl ester; $C_8H_{20}O_4Si$; [78-10-4]	11.52	- 5.4
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COMPONENTS:		ORIGINAL MEASUREMENTS:		
1. Hydrogen selenide; H ₂ Se; [7783-07-5] 2. Water; H ₂ O; [7732-18-5]		McAmis, A.J.; Felsing, W.A. <i>J. Am. Chem. Soc.</i> <u>1925</u> , 4, 2633-2637		
VARIABLES:		PREPARED BY:		
Temperature		C.L. Young		
EXPERIMENTAL VALUES:				
$P_{\text{H}_2\text{Se}} = 760 \text{ mmHg} = 101.3 \text{ kPa}$				
T/°C	T/K	No. of determinations (Av. devn.%)	Moles H ₂ Se per dm ³ of soln. +	Mole fraction of H ₂ Se, $x_{\text{H}_2\text{Se}}$
14.6	287.8	5 (0.14)	0.09789	0.00176
15.0	288.2	5 (0.29)	0.09611	0.00173
25.0	298.2	6 (0.21)	0.08415	0.00152
25.6	298.8	4 (0.41)	0.08277	0.00149
35.0	308.2	4 (0.23)	0.07317	0.00132
+ it appears that this concentration is, as indicated, in units of mol dm ⁻³ (soln) rather than mol dm ⁻³ (water). It has been assumed that the molar volume of the solution is the same as that of water for the purpose of calculating the mole fraction.				
AUXILIARY INFORMATION				
METHOD/APPARATUS/PROCEDURE:		SOURCE AND PURITY OF MATERIALS:		
Hydrogen selenide bubbled into water until saturated at the stated temperatures. Samples of saturated solutions removed and analysed either volumetrically or gravimetrically. The gravimetric method was based on the reaction between silver nitrate and hydrogen selenide. In the volumetric method saturated sample added to an excess of standard iodine solution, the selenium allowed to settle, and the excess iodine solution titrated against thiosulfate solution.		1. Prepared by action of water on aluminium selenide.		
		2. Boiled and distilled.		
		ESTIMATED ERROR:		
		$\delta T/K = \pm 0.1; \delta x_{\text{H}_2\text{Se}} = \pm 2\%$		
		REFERENCES:		

COMPONENTS:		ORIGINAL MEASUREMENTS:	
1. Hydrogen selenide; H ₂ Se; [7783-07-5]		Dubeau, C.; Sisi, J.-C.;	
2. Water; H ₂ O; [7732-18-5]		Ozanne, N.	
		<i>J. Chem. Engng. Data</i>	
		<u>1971, 16, 78-79.</u>	
VARIABLES:		PREPARED BY:	
Temperature		C. L. Young	
EXPERIMENTAL VALUES:			
Partial pressure = 1 atm = 101.3 kPa			
T/°C	T/K	Solubility [#]	Mole fraction [§] of hydrogen selenide, x _{H₂Se}
25.1	298.25	0.08347	0.00150
		0.08289	0.00149
26.6	299.75	0.08062	0.00145
		0.08031	0.00145
28.0	301.15	0.07943	0.00143
		0.07909	0.00143
29.5	302.65	0.07709	0.00139
		0.07675	0.00138
31.1	304.25	0.0757	0.00136
		0.07533	0.00136
33.0	306.15	0.07091	0.00128
		0.07133	0.00129
34.7	307.85	0.06913	0.00125
		0.06915	0.00125
36.7	309.85	0.06647	0.00120
		0.06613	0.00119
39.0	312.15	0.06338	0.00114
		0.06331	0.00114
41.0	314.15	0.06097	0.00110
		0.06141	0.00111
(cont.)			
AUXILIARY INFORMATION			
METHOD/APPARATUS/PROCEDURE:		SOURCE AND PURITY OF MATERIALS:	
Sample of water saturated with hydrogen selenide at lowest experimental temperature and sample withdrawn after 15 days. Temperature increased and after 4 hrs another sample withdrawn. Samples analyzed by gravimetric analysis using silver nitrate as precipitating agent. Details in source.		1. Matheson sample, purity 98 mole per cent.	
		2. Deoxygenated and demineralised.	
		ESTIMATED ERROR:	
		δT/K = ±0.1; δS = ±1% up to 50 °C and ±2% above 50 °C (estimated by compiler).	
		REFERENCES:	

COMPONENTS:		ORIGINAL MEASUREMENTS:	
1. Hydrogen selenide; H ₂ Se; [7783-07-5]		Dubeau, C.; Sisi, J.-C.;	
2. Water; H ₂ O; [7732-18-5]		Ozanne, N.	
		<i>J. Chem. Engng. Data</i>	
		<u>1971</u> , 16, 78-79.	
EXPERIMENTAL VALUES:			
T/°C	T/K	Solubility [#]	Mole fraction [§] of hydrogen selenide, $x_{\text{H}_2\text{Se}}$
43.0	316.15	0.05922	0.00107
		0.06033	0.00109
45.0	318.15	0.05833	0.00105
		0.05643	0.00102
47.0	320.15	0.05544	0.00100
		0.05504	0.000992
49.0	322.15	0.05361	0.000967
		0.05297	0.000955
51.0	324.15	0.05249	0.000947
		0.05161	0.000931
53.0	326.15	0.05079	0.000916
		0.05073	0.000915
55.0	328.15	0.05012	0.000904
		0.0487	0.000878
57.4	330.55	0.04672	0.000843
		0.04744	0.000856
59.0	332.15	0.04587	0.000827
		0.04384	0.000791
61.0	334.15	0.04465	0.000805
		0.04299	0.000775
63.0	336.15	0.04397	0.000793
		0.04197	0.000757
65.0	338.15	0.04377	0.000790
		0.04214	0.000760
		0.04255	0.000767
66.0	339.15	0.04228	0.000763
		0.04269	0.000770
		0.0440	0.000794
70.0	343.15	0.04017	0.000725
<p>[#] Moles of H₂Se per dm³ of solution.</p> <p>[§] Calculated by compiler assuming that 1 dm³ of solution contains 55.4 moles. It seems likely that the volume was measured at room temperature. The effect of the H₂Se on the density of water has been neglected.</p>			

COMPONENTS:		ORIGINAL MEASUREMENTS:		
1. Hydrogen selenide; H ₂ Se; (7783-07-5)		McAmis, A.J. Felsing, W.A.		
2. Hydrogen iodide; HI; [10034-85-2]		J. Am. Chem. Soc. <u>1925</u> , 4, 2633-2637		
3. Water; H ₂ O; [7732-18-5]				
VARIABLES:		PREPARED BY:		
Concentration of comp. 2.		C.L. Young		
EXPERIMENTAL VALUES:				
T/°C	T/K	Conc. of HI/mol dm ⁻³	No. of determinations (Av.devn. %)	Conc. of H ₂ Se, S/mol dm ⁻³ (soln)
25	298.2	0.20	4 (0.31)	0.08478
		0.40	4 (0.31)	0.08634
		2.73	4 (0.82)	0.11012
Total pressure = 760 mmHg = 1.013 bar				
AUXILIARY INFORMATION				
METHOD/APPARATUS/PROCEDURE:		SOURCE AND PURITY OF MATERIALS:		
Hydrogen selenide bubbled into hydriodic acid until saturated at the stated temperature. Samples of saturated solutions removed and analysed by volumetric method. A saturated sample was added to an excess of standard iodine solution, the selenium allowed to settle and the excess iodine solution titrated against thiosulfate solution.		1. Prepared by action of water on aluminium selenide.		
		2. and 3.		
		Hydrogen iodide prepared by reaction of red phosphorus and iodine in the presence of water was dissolved in conductivity water.		
		ESTIMATED ERROR:		
		$\delta T/K = \pm 0.1$; $\delta S = \pm 2\%$		
		REFERENCES:		