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Equilibrium relative humidities over saturated salt solutions

Scope

The air space immediately surrounding a saturated salt solution will, after several hours, achieve an equilibrium relative humidity that is different for different salts. Hence, saturated salt solutions are useful for controlling relative humidity in small chambers, and for checking the accuracy of electronic humidity sensors.

The salts listed in Table 1 have been selected because of their relative insensitivity to temperature changes. Values for other salts can be found in most chemistry handbooks.

Safety precautions

There are no safety precautions associated with this TIP.

TIP Category: Data and Calculations
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Content

Table 1. Percent relative humidity at various temperatures.

Solid salt phase	Temperature, °C						
	10	20	25	30	40	50	60 80
Potassium sulfate, K_2SO_4	98.2	97.6	97.3	97.0	96.4	95.8	
Ammonium phosphate, monobasic, $NH_4H_2PO_4$		93.2	92.6	92.0	90.8	(89.6)	(Note 1)
Barium chloride, $BaCl_2 \cdot 2H_2O$	91.4	90.4	89.9	89.4	88.4	87.4	
Potassium chromate, K_2CrO_4		86.6	86.4	86.3	85.3		
Potassium chloride, KCl	87.9	86.7	86.1	85.5	84.3		81.9 79.5
Ammonium sulfate, $(NH_4)_2SO_4$	82.1	81.3	81.0	80.6	79.9	79.2	
Sodium chloride, NaCl	76	75.7	75.3	74.9	74.7		
Cupric chloride, $CuCl_2 \cdot 2H_2O$	68.4	68.4	68.4	68.4			
Sodium nitrite, $NaNO_2$		65.4	64.4	63.3	61.4	59.5	(Note 2)
Sodium bromide, $NaBr \cdot 2H_2O$	62.2	59.1	57.8	56.0	53.2	50.9	(Note 2; 3)
Magnesium nitrate, $Mg(NO_3)_2 \cdot 6H_2O$	57.4	54.4	52.9	51.4	48.4	45.4	(Note 2)
Potassium nitrite, KNO_2		49.1	48.2	47.2	45.6		
Potassium carbonate, $K_2CO_3 \cdot 2H_2O$	43.1	43.2	43.2	43.2	43.3		
Sodium iodide, $NaI \cdot 2H_2O$	41.3	40.0	38.2	36.2	32.9		(Note 2; 4)
Magnesium chloride, $MgCl_2 \cdot 6H_2O$	34	33	33.0	33	32		30
Potassium acetate, $CH_3COOK \cdot 1.5H_2O$	24.5	23.4	22.5	21.6	20.8		
Lithium chloride, $LiCl \cdot H_2O$	11.3	11.3	11.3	11.3	11.2	11.1	(Note 5)
Sodium hydroxide, $NaOH \cdot H_2O$		8.9	8.2	7.6	6.3	4.9	(Note 6)

ALWAYS HAVE EXCESS SOLID SALT CRYSTALS VISIBLE IN SOLUTION TO ASSURE SATURATION AND PREVENT SUPERSATURATION. Solubility data for these salts can be found in most handbooks of chemistry.

NOTES:

1. Value at 50°C extrapolated from 45°C.
2. These are solutions with larger temperature coefficients; hence, tighter temperature tolerances are necessary.
3. Transition point at 50.6°C: $NaBr \cdot 2H_2O \rightarrow NaBr + 2H_2O$
4. Transition point at 68.1°C: $NaI \cdot 2H_2O \rightarrow NaI + 2H_2O$
5. Transition point at 18.8°C: $LiCl \cdot 2H_2O \rightarrow LiCl + 2H_2O$
6. Transition point at 64.3°C: $NaOH \cdot H_2O \rightarrow NaOH + H_2O$

When using saturated salt solutions for humidity control, attainment of equilibrium RH may be slow. The humidity chamber should be sealed and constructed of non-hygroscopic material. Air circulation is recommended. Temperature coefficients are important (Note 2); thus, thermal equilibrium of the chamber, contents, saturated salt solution, and surroundings must be achieved and maintained. When going from higher to lower humidities, the solutions should be agitated, mixed, or have mounds of salt protruding above the liquid. Materials being conditioned may attain equilibrium in the RH chamber very slowly. Salts that decompose, hydrolyze, or undergo reactions with components in air will not give satisfactory results over an extended period of use. Because of these factors, use of saturated salt solutions may not control RH closer than 1-2% of the accepted empirical values. Measurement of actual RH by some direct method should be considered for most accurate work.

For the 1992 revision of this TIP, additional values (6) were added to Table 1 to extend the temperature range to 80°C; for those salts affected, all temperature/relative humidity data has been taken from reference 6.

Keywords

Equilibrium, Humidity, Inorganic salts, Solutions



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