Chemical Properties

pН

Aqua ammonia (ammonium hydroxide) is classified as a weak base. It ionizes much less completely in water than does a strong base such as sodium hydroxide. This is reflected in the pH's normally encountered with solutions of ammonia. Typically, the pH of an ammonia solution will be between 11 and 12, compared with a pH of about 14 for sodium hydroxide solutions. The theoretical pH's below are for ammonia in pure water at 77°F.

<u>Wt.%</u>

<u>NH</u> 3	<u>Normality</u>	<u>pH %</u>	<u>lonized</u>
17.0	10.0	12.1	
1.7	1.0	11.6	0.42
0.17	0.1	11.1	1.33
0.017	0.01	10.6	4.15
0.0017	0.001	10.1	12.52

Dissociation

Dissociation Constants (Kb's) of Aqua Ammonia From 0°C to 50°C

<u>Temperature °C</u>	<u>pKb</u>	<u>Kb</u>
0	4.862	1.374 x 10 ⁻⁵
5	4.830	1.479 x 10 ⁻⁵
10	4.804	1.570 x 10 ⁻⁵
15	4.782	1.652 x 10 ⁻⁵
20	4.767	1.710 x 10 ⁻⁵
25	4.751	1.774 x 10 ⁻⁵
30	4.740	1.820 x 10 ⁻⁵
35	4.733	1.849 x 10 ⁻⁵
40	4.730	1.862 x 10 ⁻⁵
45	4.726	1.879 x 10 ⁻⁵
50	4.723	1.892 x 10 ⁻⁵

 ± 0.005 , determined by emf method by R.G. Bates and G.D. Pinching

Note: pKb = pKw-pKa

where pKw = 14 and $pKa = [H+]{NH_3}/[NH4+]$

Heat of Solution

When liquid anhydrous ammonia is dissolved in water, heat is liberated which varies with the final

concentration of aqua ammonia produced.

<u>Final Wt % NH3</u>	<u>BTU/lb. NH3</u>
10.0	343.8
20.0	328.5
30.0	308.2
40.0	270.0
50.0	218.8

Reactivity

Aqua ammonia will react with many organic and inorganic acids to form ammonium salts and compounds; with certain metals to form complexion salts; with halogens to form haloamines (such as its reaction with sodium hypochlorite [bleach] to form toxic chloramines); and under extreme circumstances with silver and mercury to form explosive azides.

Aqua ammonia corrodes copper (and coppercontaining alloys such as brass), zinc, cadmium and silver.

For chemical corrosivity information, see the Materials Compatibility section on page 6.

Physical Properties

Aqua ammonia is a clear, colorless liquid having a strong pungent ammonia odor.

Specific Gravity

The specific gravity of aqua ammonia is customarily expressed as its density at 60°F compared to the density of water at 60°F. Comprehensive tables of specific gravity, as well as corrections to use for temperature variations, are presented on pages 16-20 in Appendix A.

$\begin{array}{c c c c c c c c c c c c c c c c c c c $	<u>Weight %</u> Ammonia	<u>Specific Gravity</u> at 60°F/60°F	<u>Degrees</u> Baumé	<u>Weight %</u> Ammonia	<u>Specific Gravity</u> at 60°F/60°F	<u>Degrees</u> Baumé
0.40 0.9964 10.25 21.12 0.9216 21.75 0.80 0.9964 10.50 21.60 0.9211 22.00 1.21 0.9947 10.75 22.08 0.9195 22.25 1.62 0.9929 11.00 22.56 0.9180 22.50 2.46 0.9894 11.55 23.04 0.9155 23.00 2.88 0.9876 11.75 24.01 0.9135 23.50 3.73 0.9842 12.25 24.99 0.9106 23.75 4.16 0.9855 12.50 25.48 0.9091 24.00 4.59 0.9807 12.75 25.97 0.9076 24.25 5.02 0.9790 13.00 26.46 0.9047 24.75 5.88 0.9756 13.50 27.44 0.9032 25.00 6.74 0.9722 14.00 28.42 0.9003 25.55 7.17 0.9705 14.25 28.91 0.8989 25.75	0.00	1 0000	<u>Duunie</u> 10.00	20.64	0 9241	<u>21 50</u>
0.80 0.994 10.50 1.12 0.9211 22.00 1.21 0.9947 10.75 22.08 0.9195 22.25 1.62 0.9929 11.00 22.56 0.9180 22.50 2.04 0.9912 11.25 25.04 0.9165 22.75 2.46 0.9894 11.50 23.52 0.9150 23.00 2.88 0.9876 11.75 24.01 0.9155 23.52 3.73 0.9842 12.25 24.99 0.9106 23.75 4.16 0.8825 12.50 25.48 0.9091 24.00 4.59 0.9807 12.75 25.97 0.9076 24.25 5.02 0.97790 13.00 26.46 0.9061 24.50 5.45 0.9773 13.25 26.95 0.9047 24.75 5.88 0.9765 13.50 27.44 0.9032 25.00 6.31 0.9722 14.00 28.42 0.9003 25.75	0.40	0.9982	10.25	21.12	0.9226	21.33
1.21 0.9367 10.75 12.06 0.121 12.07 1.21 0.9929 11.00 22.56 0.9180 22.50 2.04 0.9912 11.25 23.04 0.9165 22.75 2.46 0.9894 11.50 25.52 0.9150 23.00 2.88 0.8876 11.75 24.01 0.9135 23.25 3.30 0.9859 12.00 24.50 0.9106 23.75 4.16 0.9825 12.25 25.97 0.9076 24.25 5.02 0.9807 12.75 25.97 0.9076 24.50 5.45 0.9773 13.25 26.95 0.9047 24.75 5.88 0.9756 13.50 27.44 0.9032 25.50 7.17 0.9705 14.25 28.91 0.8898 25.75 7.61 0.9689 14.50 29.40 0.8974 26.00 8.05 0.9672 14.75 29.89 0.8960 26.25	0.80	0.9964	10.50	21.60	0.9211	22.00
1.1.20.93171.0.71.0.71.0.80.71801.2.51.620.991711.2523.040.916522.752.460.989411.5023.520.915023.002.880.987611.7524.010.913523.253.300.985912.0024.500.912123.503.730.984212.2524.990.910623.754.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.020.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.310.973913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2529.890.886026.258.490.965515.0030.380.894626.508.930.965915.2531.360.893126.759.380.960515.7531.850.880327.2510.280.958916.0032.340.883328.5012.200.958916.2533.320.886128.0011.640.954016.7533.810.884728.2512.560.950817.2534.790.881928.7513.900.942817.50 </td <td>1 21</td> <td>0.9947</td> <td>10.30</td> <td>22.08</td> <td>0.9211</td> <td>22.00</td>	1 21	0.9947	10.30	22.08	0.9211	22.00
1020.92511.0022.500.916522.752.040.991211.2525.040.916522.752.460.989411.5023.520.915023.002.880.987611.7524.010.913523.253.300.988912.0024.500.912123.503.730.984212.2524.990.910623.754.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.420.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.510.973913.7527.930.901825.256.740.972214.0028.420.900525.507.170.970514.2528.910.8896026.258.490.965515.0030.380.894626.508.930.962215.5031.360.891727.009.830.962215.5031.850.880327.2510.730.957316.2532.830.884728.2511.640.954016.7533.810.884728.2512.100.954117.0034.300.883328.5013.490.947517.75Data of Ferguson from Lange's Handbook of13.490.944418.25Pr	1.21	0.9947	11.00	22.00	0.9199	22.25
2.460.931211.2525.540.716523.002.880.987611.7524.010.913523.523.300.989912.0024.500.912123.503.730.984212.2524.990.910623.754.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.020.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.740.972214.0028.420.900325.507.170.970514.2528.910.898925.757.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.891126.759.380.962215.5031.360.891727.009.830.962215.7531.850.890327.2510.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.5012.260.950817.2534.790.881328.5013.400.944418.25 Pressure 114.430.944418.25 Pressure 114.430.944418.25 Pressure 1<	2.04	0.0012	11.00	22.50	0.9165	22.30
2.400.536411.502.5.20.51502.5.002.880.987611.7524.010.913523.253.300.985912.0024.500.912123.503.730.984212.2524.990.910623.754.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.020.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.310.9773913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2528.910.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.966315.7531.860.891727.009.830.960515.7531.850.880327.2510.280.958916.0032.340.884927.5010.730.957316.2532.830.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881328.5013.490.947517.75Data	2.04	0.9912	11.25	23.04	0.9150	22.75
2.850.987011.7524.010.912123.503.700.985912.0024.500.912123.503.730.984212.2524.990.910623.754.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.020.9779013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.740.972214.0028.420.900325.507.170.970514.2528.910.889925.757.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.9663915.2530.870.893126.759.380.9663915.7531.850.800327.2510.280.958916.0032.340.888927.5011.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5055.280.880529.0013.490.947517.75Dat	2.40	0.9094	11.50	23.32	0.9130	23.00
3.500.980912.0024.300.911623.373.730.984212.2524.990.910623.754.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.020.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.310.973913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2528.910.889925.757.610.9668914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.966215.7531.850.890327.2510.280.958916.0032.340.884728.2511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.5012.560.950817.2534.790.881928.7513.020.944217.0034.300.883328.5012.560.950817.2534.790.881928.7513.090.947517.75Data	2.00	0.9870	12.00	24.01	0.9133	23.23
3.7.30.564212.2.324.990.910025.734.160.982512.5025.480.909124.004.590.980712.7525.970.907624.255.020.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.310.973913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2528.910.898925.757.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.960215.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.805529.0013.490.947517.75Dat	J.J0 Z 7Z	0.9839	12.00	24.30	0.9121	23.30
4.160.562.312.5023.480.907124.004.590.980712.7525.970.907624.255.020.977013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.310.973913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2528.910.898925.757.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.893126.759.380.9663915.2530.870.893126.759.380.966215.7531.850.890327.2510.280.958916.0032.340.888927.5011.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.944917.5055.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00 <td>J.7J 4 16</td> <td>0.9042</td> <td>12.23</td> <td>24.99</td> <td>0.9100</td> <td>23.73</td>	J.7J 4 16	0.9042	12.23	24.99	0.9100	23.73
4.590.980712.7525.970.907624.255.020.979013.0026.460.906124.505.450.977313.2526.950.904724.755.880.975613.5027.440.903225.006.310.973913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2528.910.889925.757.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.962215.5031.360.891727.009.830.960515.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.944218.00Chemistry (5th Edition).44.4014.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).44.4014.490.942818.	4.10	0.9823	12.50	25.40	0.9091	24.00
3.02 0.9790 13.00 26.46 0.9047 24.75 5.45 0.9773 13.25 26.95 0.9047 24.75 5.88 0.9756 13.50 27.44 0.9032 25.00 6.31 0.9739 13.75 27.93 0.9018 25.25 6.74 0.9722 14.00 28.42 0.9003 25.50 7.17 0.9705 14.25 28.91 0.8989 25.75 7.61 0.9689 14.50 29.40 0.8974 26.00 8.05 0.9672 14.75 29.89 0.8960 26.25 8.49 0.9655 15.00 30.38 0.8946 26.50 8.93 0.9639 15.25 30.87 0.8931 26.75 9.38 0.9622 15.50 31.36 0.8917 27.00 9.83 0.9605 15.75 31.85 0.8903 27.25 10.28 0.9589 16.00 32.34 0.8889 27.50 10.73 0.9573 16.25 32.83 0.8875 27.75 11.18 0.9556 16.50 33.32 0.8861 28.00 11.64 0.9540 16.75 33.81 0.8847 28.25 12.10 0.9524 17.00 34.30 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 15.37	4.59	0.9807	12.75	25.97	0.9076	24.23
5.45 0.9775 13.25 26.95 0.9047 24.75 5.88 0.9756 13.50 27.44 0.9032 25.00 6.31 0.9739 13.75 27.93 0.9018 25.25 6.74 0.9722 14.00 28.42 0.9003 25.50 7.17 0.9705 14.25 28.91 0.8989 25.75 7.61 0.9689 14.50 29.40 0.8974 26.00 8.05 0.9672 14.75 29.89 0.8960 26.25 8.49 0.9655 15.00 30.38 0.8946 26.50 8.93 0.9639 15.25 30.87 0.89311 26.75 9.38 0.9622 15.50 31.36 0.8917 27.00 9.83 0.9605 15.75 31.85 0.8803 27.25 10.28 0.9589 16.00 32.34 0.8889 27.50 10.73 0.9573 16.25 32.83 0.8875 27.75 11.18 0.9556 16.50 33.32 0.8861 28.00 11.64 0.9540 16.75 33.81 0.8833 28.50 12.56 0.9508 17.25 54.79 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 13.96 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia 15.37 0.9365 19.00 due t	5.02	0.9790	13.00	26.46	0.9061	24.50
5.88 0.9756 13.50 27.44 0.9032 25.00 6.31 0.9739 13.75 27.93 0.9018 25.25 6.74 0.9722 14.00 28.42 0.9003 25.50 7.17 0.9705 14.25 28.91 0.8989 25.75 7.61 0.9689 14.50 29.40 0.8974 26.00 8.05 0.9672 14.75 29.89 0.8960 26.25 8.49 0.9655 15.00 30.38 0.8946 26.50 8.93 0.9639 15.25 30.87 0.8931 26.75 9.38 0.9622 15.50 31.36 0.8917 27.00 9.83 0.9605 15.75 31.85 0.8903 27.25 10.28 0.9589 16.00 32.34 0.8889 27.50 10.73 0.9573 16.25 32.83 0.8875 27.75 11.18 0.9556 16.50 33.32 0.8861 28.00 11.64 0.9540 16.75 35.81 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 55.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 13.96 0.9444 18.25 Pressure 14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure o	5.45	0.9773	13.25	26.95	0.9047	24.75
6.310.973913.7527.930.901825.256.740.972214.0028.420.900325.507.170.970514.2528.910.898925.757.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.966515.7531.360.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of15.370.941218.75solution is comprised of the partial vapor pressure due to14.900.942818.50The total vapor pressure of an aqua ammonia15.370.941218.75solution is comprised of the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bul	5.88	0.9756	13.50	27.44	0.9032	25.00
6.74 $0.9/22$ 14.00 28.42 0.9003 25.50 7.17 0.9705 14.25 28.91 0.8989 25.75 7.61 0.9689 14.50 29.40 0.8974 26.00 8.05 0.9672 14.75 29.89 0.8960 26.25 8.49 0.9655 15.00 30.38 0.8946 26.50 8.93 0.9639 15.25 30.87 0.8931 26.75 9.38 0.9622 15.50 31.36 0.8917 27.00 9.83 0.9605 15.75 31.85 0.8903 27.25 10.28 0.9589 16.00 32.34 0.8889 27.50 10.73 0.9573 16.25 32.83 0.8861 28.00 11.64 0.9540 16.75 33.81 0.8847 28.25 12.10 0.9524 17.00 34.30 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 35.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 15.37 0.9412 18.75 solution is comprised of the partial vapor pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia 15.37 0.9412 18.75 solution is comprised of the partial vapor pressure due to 16.32 0.9380 19.25 H2O. Information on these pre	6.31	0.9739	13.75	27.93	0.9018	25.25
7.17 0.9705 14.25 28.91 0.8989 25.75 7.61 0.9689 14.50 29.40 0.8974 26.00 8.05 0.9672 14.75 29.89 0.8960 26.25 8.49 0.9655 15.00 30.38 0.8946 26.50 8.93 0.9639 15.25 30.87 0.8931 26.75 9.38 0.9662 15.50 31.36 0.8917 27.00 9.83 0.9605 15.75 31.85 0.8903 27.25 10.28 0.9589 16.00 32.34 0.8889 27.50 10.73 0.9573 16.25 32.83 0.8875 27.75 11.18 0.9556 16.50 33.32 0.8861 28.00 11.64 0.9540 16.75 33.81 0.8847 28.25 12.10 0.9524 17.00 34.30 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 35.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 13.96 0.9444 18.25 Pressure 14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia 15.37 0.9360 19.00 due to NH ₃ plus the partial vapor pressure due to 16.32 0.9365 19.50 funct	6.74	0.9722	14.00	28.42	0.9003	25.50
7.610.968914.5029.400.897426.008.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.960515.7531.360.891727.009.830.960515.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25Pressure15.370.941218.75solution is comprised of the partial vapor pressure due to16.320.936519.00due to NH_3 plus the partial vapor pressure due to16.320.934919.75Technical Bulletin TB-9.1, which is reproduced in17.280.934919.75Technical Bulletin TB-9.1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables <td>7.17</td> <td>0.9705</td> <td>14.25</td> <td>28.91</td> <td>0.8989</td> <td>25.75</td>	7.17	0.9705	14.25	28.91	0.8989	25.75
8.050.967214.7529.890.896026.258.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.962215.5031.360.891727.009.830.960515.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia solution is comprised of the partial vapor pressure15.370.941218.75solution is comprised of the partial vapor pressure16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables	7.61	0.9689	14.50	29.40	0.8974	26.00
8.490.965515.0030.380.894626.508.930.963915.2530.870.893126.759.380.962215.5031.360.891727.009.830.960515.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.4314.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia15.370.941218.75solution is comprised of the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprihensive tables	8.05	0.9672	14.75	29.89	0.8960	26.25
8.93 0.9639 15.25 30.87 0.8931 26.75 9.38 0.9622 15.50 31.36 0.8917 27.00 9.83 0.9605 15.75 31.85 0.8903 27.25 10.28 0.9589 16.00 32.34 0.8889 27.50 10.73 0.9573 16.25 32.83 0.8875 27.75 11.18 0.9556 16.50 33.32 0.8861 28.00 11.64 0.9540 16.75 33.81 0.8847 28.25 12.10 0.9524 17.00 34.30 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 35.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 13.96 0.9444 18.25 Pressure 14.43 0.9444 18.25 Pressure 14.43 0.9444 18.25 15.37 0.9412 18.75 solution is comprised of the partial vapor pressure due to 16.32 0.9380 19.25 H2O. Information on these pressures as a 16.80 16.80 0.9365 19.50 function of temperature is provided in Airgas 17.28 0.9349 19.75 Technical Bulletin TB-9.1, which is reproduced in 17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables	8.49	0.9655	15.00	30.38	0.8946	26.50
9.380.962215.5031.360.891727.009.830.960515.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia solution is comprised of the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9.1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables00.933320.00Appendix A, page 21. More comprehensive tables	8.93	0.9639	15.25	30.87	0.8931	26.75
9.830.960515.7531.850.890327.2510.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia solution is comprised of the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.933320.00Appendix A, page 21. More comprehensive tables17.760.933320.00Appendix A, page 21. More comprehensive tables	9.38	0.9622	15.50	31.36	0.8917	27.00
10.280.958916.0032.340.888927.5010.730.957316.2532.830.887527.7511.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia solution is comprised of the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a 16.800.936517.280.934919.75Technical Bulletin TB-9.1, which is reproduced in Appendix A, page 21. More comprehensive tables17.760.933320.00Appendix A, page 21. More comprehensive tables	9.83	0.9605	15.75	31.85	0.8903	27.25
10.73 0.9573 16.25 32.83 0.8875 27.75 11.18 0.9556 16.50 33.32 0.8861 28.00 11.64 0.9540 16.75 33.81 0.8847 28.25 12.10 0.9524 17.00 34.30 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 35.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of 13.96 0.9459 18.00 Chemistry (5th Edition). 14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia 15.37 0.9412 18.75 solution is comprised of the partial vapor pressure 16.80 0.9365 19.00 due to NH3 plus the partial vapor pressure due to 16.80 0.9365 19.50 function of temperature is provided in Airgas 17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in 17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 10.04 0.9234 0.9234 0.9234	10.28	0.9589	16.00	32.34	0.8889	27.50
11.180.955616.5033.320.886128.0011.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia solution is comprised of the partial vapor pressure15.840.939619.00due to NH3 plus the partial vapor pressure due to16.320.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9.1, which is reproduced in Appendix A, page 21. More comprehensive tables17.760.933320.00Appendix A, page 21. More comprehensive tables	10.73	0.9573	16.25	32.83	0.8875	27.75
11.640.954016.7533.810.884728.2512.100.952417.0034.300.883328.5012.560.950817.2534.790.881928.7513.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 15.370.941218.75solution is comprised of the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables0.93100.923100.92 05of this relations for a presented in Appendix A	11.18	0.9556	16.50	33.32	0.8861	28.00
12.10 0.9524 17.00 34.30 0.8833 28.50 12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 35.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of13.96 0.9459 18.00 Chemistry (5th Edition).14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia15.37 0.9412 18.75 solution is comprised of the partial vapor pressure due to16.32 0.9380 19.25 H2O. Information on these pressures as a16.80 0.9365 19.50 function of temperature is provided in Airgas17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 0.6710 0.97310 0.9740 0.9740	11.64	0.9540	16.75	33.81	0.8847	28.25
12.56 0.9508 17.25 34.79 0.8819 28.75 13.02 0.9492 17.50 35.28 0.8805 29.00 13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of13.96 0.9459 18.00 Chemistry (5th Edition).14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia15.37 0.9412 18.75 solution is comprised of the partial vapor pressure15.84 0.9396 19.00 due to NH_3 plus the partial vapor pressure due to16.32 0.9380 19.25 H2O. Information on these pressures as a16.80 0.9365 19.50 function of temperature is provided in Airgas17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 0.9718 0.9718 0.9718 0.9718	12.10	0.9524	17.00	34.30	0.8833	28.50
13.020.949217.5035.280.880529.0013.490.947517.75Data of Ferguson from Lange's Handbook of13.960.945918.00Chemistry (5th Edition).14.430.944418.25 Pressure 14.900.942818.50The total vapor pressure of an aqua ammonia15.370.941218.75solution is comprised of the partial vapor pressure15.840.939619.00due to NH_3 plus the partial vapor pressure due to16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables10.840.934919.75of this relationship are presented in Appendix A	12.56	0.9508	17.25	34.79	0.8819	28.75
13.49 0.9475 17.75 Data of Ferguson from Lange's Handbook of13.96 0.9459 18.00 Chemistry (5th Edition).14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia15.37 0.9412 18.75 solution is comprised of the partial vapor pressure15.84 0.9396 19.00 due to NH ₃ plus the partial vapor pressure due to16.32 0.9380 19.25 H2O. Information on these pressures as a16.80 0.9365 19.50 function of temperature is provided in Airgas17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 0.9710 0.9710 0.9710 0.9710	13.02	0.9492	17.50	35.28	0.8805	29.00
13.96 0.9459 18.00 Chemistry (5th Edition).14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia15.37 0.9412 18.75 solution is comprised of the partial vapor pressure15.84 0.9396 19.00 due to NH ₃ plus the partial vapor pressure due to16.32 0.9380 19.25 H2O. Information on these pressures as a16.80 0.9365 19.50 function of temperature is provided in Airgas17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 0.9216 0.9216 0.9216 0.9216	13.49	0.9475	17.75	Data of Ferguso	on from Lange's Hand	lbook of
14.43 0.9444 18.25 Pressure 14.90 0.9428 18.50 The total vapor pressure of an aqua ammonia15.37 0.9412 18.75 solution is comprised of the partial vapor pressure15.84 0.9396 19.00 due to NH_3 plus the partial vapor pressure due to16.32 0.9380 19.25 H2O. Information on these pressures as a16.80 0.9365 19.50 function of temperature is provided in Airgas17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 0.9218 0.9718 0.9718	13.96	0.9459	18.00	Chemistry (5th	Edition).	
14.90 0.9428 18.50The source15.37 0.9412 18.75The total vapor pressure of an aqua ammonia solution is comprised of the partial vapor pressure due to NH3 plus the partial vapor pressure due to15.84 0.9396 19.00due to NH3 plus the partial vapor pressure due to16.32 0.9380 19.25H2O. Information on these pressures as a16.80 0.9365 19.50function of temperature is provided in Airgas17.28 0.9349 19.75Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00Appendix A, page 21. More comprehensive tables06 this relationship are presented in Appendix A	14.43	0.9444	18.25	Pressure	,	
15.37 0.9412 18.75 Ine total vapor pressure of an aqua ammonia15.84 0.9396 19.00 due to NH3 plus the partial vapor pressure due to16.32 0.9380 19.25 H2O. Information on these pressures as a16.80 0.9365 19.50 function of temperature is provided in Airgas17.28 0.9349 19.75 Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00 Appendix A, page 21. More comprehensive tables 0.9349 0.9349 0.9349 0.9333 0.9349 0.9349 0.9333 0.9349 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 0.9333 0.9349 <	14.90	0.9428	18.50		6	•
15.84 0.9396 19.00due to NH_3 plus the partial vapor pressure due to16.32 0.9380 19.25H2O. Information on these pressures as a16.80 0.9365 19.50function of temperature is provided in Airgas17.28 0.9349 19.75Technical Bulletin TB-9-1, which is reproduced in17.76 0.9333 20.00Appendix A, page 21. More comprehensive tables10.04 0.9710 0.9710 0.9710	15.37	0.9412	18.75	The total vapor	pressure of an aqua a	ammonia
16.320.938019.25H2O. Information on these pressures as a16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables10.240.971022.25of this relationship are presented in Appendix A	15.84	0.9396	19.00	due to NH plu	s the partial vapor pr	apor pressure
16.800.936519.50function of temperature is provided in Airgas17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in17.760.933320.00Appendix A, page 21. More comprehensive tables10.040.071020.07100.0710	16.32	0.9380	19.25	H2O Informat	ion on these pressure	
17.280.934919.75Technical Bulletin TB-9-1, which is reproduced in Appendix A, page 21. More comprehensive tables17.760.933320.00Appendix A, page 21. More comprehensive tables10.040.071020.02of this relationship are presented in Appendix A	16.80	0.9365	19.50	function of tem	perature is provided i	n Airgas
17.760.933320.00Appendix A, page 21. More comprehensive tables10.040.07100.0710	17.28	0.9349	19.75	Technical Bulletin TB-9-1 which is reproduced in		
10.04 0.0710 of this relationship are presented in Appendix A	17.76	0.9333	20.00	Appendix A, page 21. More comprehensive tables		
18.74 1.0318 20.25 of this relationship are presented in Appendix A,	18.24	0.9318	20.00	of this relationship are presented in Appendix A.		
pages 22-25. Note that any pressure due to the	18.72	0.9302	20.50	pages 22-25. Note that any pressure due to the		due to the
19 20 0 9287 20 75 presence of air in a storage tank or system is	19 20	0.9287	20.75	presence of air in a storage tank or system is		ystem is
additional to the aqua ammonia vapor pressure.	19.20	0.9272	21.00	additional to th	e aqua ammonia vap	or pressure.
20.16 0.9256 21.25	20.16	0.9256	21.00			

Solubility		<u>Weight Percent</u>	
Water and ammonia are miscible in all		<u>oj Ammonia in</u> Agua Ammonia	Freezing Point °F
proportions. When one refers to the solubility of		60.6	-113.8
solubility at a given temperature for which the		59.9	-115.1
vapor pressure is equal to	o atmospheric pressure.	59.3	-116.1
<u>Temperature °F</u>	<u>Wt. % Ammonia</u>	58.9	-117.2
	<u>Solubility</u>	57.6	-121.4
32	47.3	55.6	-119.4
50	40.6	51.6	-112.4
68	34.1	48.8	-110.4
86	29.0	48.7	-110.2
10/	25.3	47.9	-110.4
104	25.5	42.3	-117.4
122	22.1	40.8	-122.8
140	19.2	39.2	-126.8
158	16.2	38.4	-131.8
176	13.3	37.7	-133.1
194	10.2	34.4	-142.8
212	6.0	32.7	-142.1
212 6.9		31.4	-128.5
Appendix A, page 26	vs. temperature, see	28.5	-101.6
Freezing Point		27.5	-91.8
The freezing point of 29 4% ammonia is about -		26.4	-82.7
111°F		25.4	-74.9
<u>Weight Percent</u>		22.0	-46.3
<u>of Ammonia in</u>	Europeirus Doint 9E	19.3	-30.8
<u>Aqua Ammonia</u>	Freezing Point 'F	17.1	-19.5
100	-107.7	4.22	23.4
94.4	-113.6	0.00 Eutoctic I: 77 49/	32.0 149 5
89.9	-118.7	Eutectic II: 57.1%	-140.5
85.8	-123.7	Eutectic III: 80.5%	-122.0
80.7	-134.5	Data: S. Postma Recve	eil des Travaux Chimigues
77 5	-127 7	des Pays-Bas 39,515 (2	1920)
72.4	-116.0	For a graph of freezing	g point versus temperature,
69.9	-112.0	see Appendix A, page	21.
68.7	-111 5		
65.4	-109.8		
64 5	-110.0		
63.3	-110.6		

Boiling Point

The boiling point of aqua ammonia is defined as the temperature at which the partial vapor pressure of the ammonia vapor over the aqua ammonia equals atmospheric pressure.

<u>Degrees Be'</u>	<u>Weight % NH</u> 3	<u>Boiling Point</u>
<u>at 60°</u>	<u>Concentration</u>	<u>°F</u>
10	0.00	212
11	1.62	195
12	3.30	186
13	5.02	177
14	6.74	171
15	8.49	163
16	10.28	156
17	12.10	149
18	13.96	142
19	15.84	134
20	17.76	127
21	19.68	120
22	21.60	111
23	23.52	103
24	25.48	95
25	27.44	88
26	29.40	81
27	31.36	73
28	33.32	66
29	35.28	59

Viscosity

Aqua ammonia viscosity is higher than that for liquid anhydrous ammonia. The viscosities shown below are for 26% concentration aqua ammonia.

<u>Temperature</u> °F	<u>Centipoise</u>	
-40	5.0	
0	2.8	
40	1.7	
80	1.1	
120	0.7	

from Perry's *Chemical Engineer's Handbook* (1984)

Surface Tension

The surface tension of aqua ammonia at 67°F for various concentrations is shown below:

<u>% NH</u> 3	Surface Tension
3	(dynes/cm)
1.72	71.65
3.39	70.65
4.99	69.95
9.51	67.85
17.37	65.25
34.47	61.05
54.37	57.05

from Perry's *Chemical Engineer's Handbook* (1984)

Conversions

Dilutions

The calculations required to determine the volume of anhydrous ammonia or aqua ammonia of an initial concentration to mix with water to create a specific concentration aqua ammonia do not follow normal dilution rules since the anhydrous ammonia and aqua ammonia volumes are not additive with water volumes, i.e., one gallon of anhydrous ammonia added to nine gallons of water does not result in 10 gallons of solution. The final volume would be less than 10 gallons. For many aqua dilutions, the non-additive effects are minimal. For anhydrous additions, they are significant.

The steps to calculate dilutions are as follows:

1. Let $V_o =$ volume in gallons of original concentration aqua ammonia or anhydrous ammonia

 C_o = concentration in wt. % NH₃ of anhydrous ammonia or original aqua ammonia solution used

 $V_{\rm f}$ = volume in gallons of final solution desired

 C_f = concentration in wt. % NH₃ of final aqua ammonia solution desired

 $V_{\rm w}$ = volume in gallons of water to be added

2. Determine specific gravities at 60°F/60°F of both original and final concentrations of aqua ammonias by referring to tables in "Physical Properties" on page 11. Interpolation is used to