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.

Degrees Be' at 60°	***Weight % NH_3 Concentration***	***Boiling Point °F***
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.

Temperature °F	***Centipoise***
-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:

% NH_3	***Surface Tension (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. % NH_3 of anhydrous ammonia or original aqua ammonia solution used

   V_f = volume in gallons of final solution desired

   C_f = concentration in wt. % NH_3 of final aqua ammonia solution desired

   V_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

calculate intermediate values. For anhydrous ammonia, use: specific gravity = 0.6182

3. Let Sg_o = specific gravity of anhydrous ammonia or original concentration aqua ammonia

Sg_f = specific gravity of final concentration aqua ammonia

Sg_w = 1.0000 specific gravity of water

4. Two facts are known. First, the weight of the original anhydrous ammonia or aqua solution plus the weight of the water added must equal the weight of the final solution. Second, the weight of the ammonia (NH_3) present originally (either as anhydrous ammonia or in the original aqua ammonia) must equal the weight of the ammonia (NH_3) in the final solution. Therefore, two equations with two unknowns are generated from which desired values can be calculated. The "ammonia equation" becomes $(V_o)(SG_o)(C_o) = (V_f)(SG_f)(C_f)$ and the "weight equation" $(V_o)(SG_o) + V_w = (V_f)(SG_f)$.

Example: What volume anhydrous ammonia (NH_3) would you add to what volume of water to obtain 1,000 gallons of 29.4% aqua ammonia?

The "ammonia equation" becomes:

$V_o = V_f(SG_f)(C_f)/(SG_o)(C_o)$

or $V_o = 1{,}000(0.8974)(0.294)/(0.6182)(1.00)$

or $V_o = 426.7$ gallons

The "weight equation" becomes:

$V_w = (V_f)(SG_f) - (V_o)(SG_o)$

or $V_w = (1{,}000)(0.8974) - (426.7)(0.6182)$

or $V_w = 633.6$ gallons

Note that 426.7 + 633.6 does not equal 1,000. There has been a decrease of about 6% in volume in the mixing process.

References

1. Health Effects Assessment For Ammonia, Clement Associates, Inc., 1990 [Prepared for The Fertilizer Institute]

2. Reagent Chemicals, 8th Edition, 1993 American Chemical Society, Washington, D.C.

3. United States Pharmacoepia 21 - National Formulary 16, 1985 Edition, United States Pharmacoepial Convention, Inc.

4. Food Chemicals Codex, 4th Edition, 1996, National Academy Press, Washington, D.C.

5. Anhydrous Ammonia G-2-1995, 8th Edition, 1995, Compressed Gas Association, Inc.

6. Anhydrous Ammonia Safety, 1989, Airgas Industries, Inc.

7. Perry's Chemical engineers Handbook, 6th Edition, 1984, McGraw Hill Book Company