

Process Design Technical Note

TECHNICAL NOTE

AMMONIA SCRUBBING

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1.0 Ammonia Scrubbing

Atomic weight	17.03
Melting point	-77.7°C
Boiling point	-33.4 °C

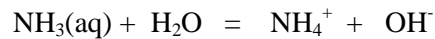
1.1 Reactions of NH₃

1.1.1 Dissolution

Extremely soluble in water when hydrates are formed; NH₃.H₂O, NH₃.2H₂O and 2NH₃.H₂O

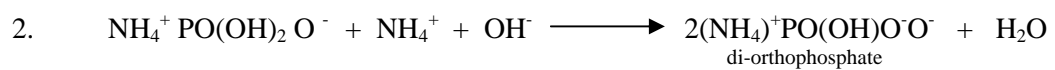
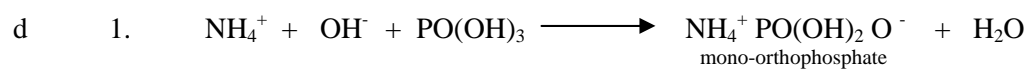
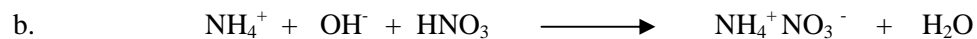
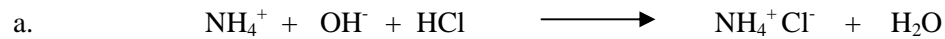
Solubility in water @ 0°C:	899g/l
@ 96°C:	74 g/l

The weak base, NH₄OH, ammonium hydroxide solution probably does not exist and is best described as NH₃(aq).



1.1.2 Ammonium Salts

Reactions with strong acids are similar with the salts formed being fully ionised. They are slightly acidic and the solubilities resemble those of potassium.



1.1 Reactions of NH₃ (Cont.)

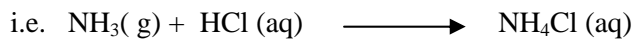
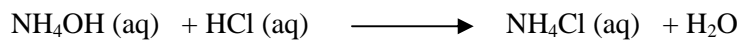
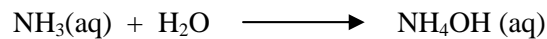
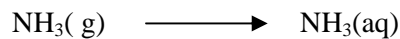
1.1.3 Solubilities

	Solubility in water @ 0°C g/l	Solubility in water @ 100°C g/l
NH ₄ Cl	294	773
NH ₄ NO ₃	1183	8710
(NH ₄) ₂ SO ₄	706	1033
NH ₄ POO(OH) ₂	227	1732

1.2 Heat of Reaction

1.2.1 Hydrochloric Acid

Heats of formation, ΔH _f @25°C	NH ₃ (g)	- 10.96 kcal/mole
	NH ₃ (aq)	- 19.27
	NH ₄ OH (aq)	- 87.59
	HCl (aq)	- 39.85
	NH ₄ Cl (aq)	- 71.20
	H ₂ O (l)	- 68.32

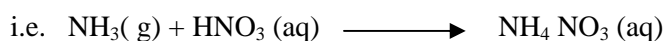
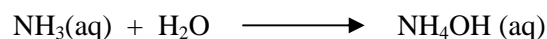
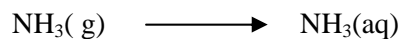


$$\begin{aligned} \text{Heat of reaction} &= -((-10.96) + (-39.85)) + (-71.20) \\ &= +50.81 - 71.20 \\ &= \underline{-20.39 \text{ kcal}} \end{aligned}$$

i.e. **20 kcal/mole ammonia** exotherm

1.2.2 Nitric Acid

Heats of formation, ΔH _f @25°C	NH ₃ (g)	- 10.96 kcal/mole
	NH ₃ (aq)	- 19.27
	NH ₄ OH (aq)	- 87.59
	HNO ₃ (aq)	- 49.21
	NH ₄ NO ₃ (aq)	- 80.89
	H ₂ O (l)	- 68.32



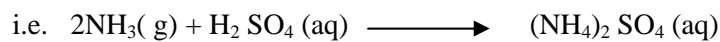
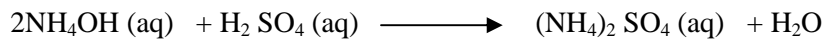
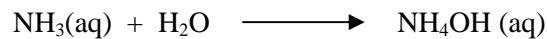
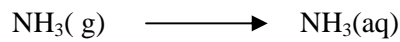
$$\begin{aligned} \text{Heat of reaction} &= -((-10.96) + (-49.21)) + (-80.89) \\ &= +60.17 - 80.89 \\ &= \underline{-20.72 \text{ kcal}} \end{aligned}$$

i.e. **21 kcal/mole ammonia** exotherm

1.2 Heat of Reaction (Cont.)

1.2.3 Sulphuric Acid

Heats of formation, ΔH_f @25°C	NH ₃ (g)	- 10.96	kcal/mole
	NH ₃ (aq)	- 19.27	
	NH ₄ OH (aq)	- 87.59	
	H ₂ SO ₄ (aq)	- 212.03	
	(NH ₄) ₂ SO ₄ (aq)	- 279.33	
	H ₂ O (l)	- 68.32	



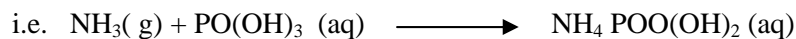
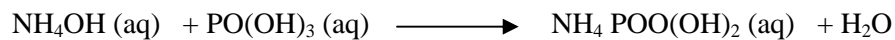
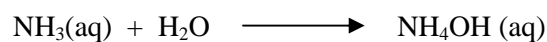
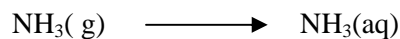
$$\begin{aligned} \text{Heat of reaction} &= -(2(-10.96) + (-212.03)) + (-279.33) \\ &= +233.95 - 279.33 \\ &= -\underline{45.38 \text{ kcal}} \end{aligned}$$

i.e. **23 kcal/mole ammonia** exotherm

1.2.4 Phosphoric Acid

It is assumed that only the monophosphate is formed.

Heats of formation, ΔH_f @25°C	NH ₃ (g)	- 10.96	kcal/mole
	NH ₃ (aq)	- 19.27	
	NH ₄ OH (aq)	- 87.59	
	PO(OH) ₃ (aq)	- 309.32	
	NH ₄ POO(OH) ₂ (aq)	- 345.38	
	H ₂ O (l)	- 68.32	



$$\begin{aligned} \text{Heat of reaction} &= -((-10.96) + (-309.32)) + (-345.38) \\ &= +320.28 - 345.38 \\ &= -\underline{25.10 \text{ kcal}} \end{aligned}$$

i.e. **25 kcal/mole ammonia** exotherm

1.3 General Considerations

The choice of scrubbing liquid depends on a number of factors that should be considered.

These include:-

1. The availability of acids which may be present already on site as a by-product or main raw material.

2. The fate of spent scrubber liquors:

Using sulphuric acid will have a deleterious effect if discharged to concrete drains.
(Most water authorities have a sulphate concentration limit on discharges to public sewer.)

If applicable, the potential effect on sewage treatment of phosphate and nitrate species.

3. The potential from the use of nitric acid to generate nitrous fumes.

4. The corrosion potential of the acids, especially hydrochloric.