

Answer on the question #62391, Chemistry / General Chemistry

Question:

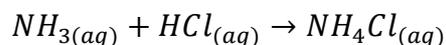
Problem 4.115 (Chapter 4)

Federal regulations set an upper limit of 50 parts per million (ppm) of NH₃ in the air in a work environment [that is, 50 molecules of NH₃(g) for every million molecules in the air]. Air from a manufacturing operation was drawn through a solution containing 106 mL of 1.13×10⁻² M HCl. The NH₃ reacts with HCl as follows: NH₃(aq)+HCl(aq)→NH₄Cl(aq) After drawing air through the acid solution for 10.0 min at a rate of 10.0 L/min, the acid was titrated. The remaining acid needed 14.5 mL of 5.86×10⁻² M NaOH to reach the equivalence point.

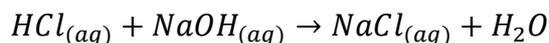
- 1) How many grams of NH₃ were drawn into the acid solution?
- 2) How many ppm of NH₃ were in the air? (Air has a density of 1.20 g/L and an average molar mass of 29.0 g/mol under the conditions of the experiment.)
- 3) Is this manufacturer in compliance with regulations?

Solution:

The reactions occur during the process:



and during the titration:



1) Let's calculate the number of the moles of chloric acid, remained in the solution and reacted with sodium hydroxide:

$$\begin{aligned} n(\text{HCl})_{\text{titration}} &= n(\text{NaOH}) = c(\text{NaOH}) \cdot V(\text{NaOH}) = 5.86 \cdot 10^{-2}(\text{M}) \cdot 14.5 \cdot 10^{-3}(\text{L}) \\ &= 8.497 \cdot 10^{-4} \text{mol} \end{aligned}$$

Then, the number of the moles of chloric acid that was used in reaction with NH₃ is:

$$\begin{aligned} n(\text{HCl})_{\text{tot}} &= n(\text{HCl})_{\text{titration}} + n(\text{HCl})_{\text{NH}_3} \\ n(\text{HCl})_{\text{NH}_3} &= n(\text{HCl})_{\text{tot}} - n(\text{HCl})_{\text{titration}} \end{aligned}$$

$$\begin{aligned} n(\text{HCl})_{\text{NH}_3} &= c(\text{HCl}) \cdot V(\text{HCl}) - n(\text{HCl})_{\text{titration}} \\ &= 1.13 \cdot 10^{-2}(\text{M}) \cdot 106 \cdot 10^{-3}(\text{L}) - 8.497 \cdot 10^{-4}(\text{mol}) \\ &= 3.481 \cdot 10^{-4}(\text{mol}) \end{aligned}$$

The number of the moles of NH₃ is equal to the number of the moles of HCl used for NH₃ trap:

$$n(\text{HCl})_{\text{NH}_3} = n(\text{NH}_3)$$

So, we simply multiply the number of the moles of NH₃ by its molar mass to get the mass of NH₃:

$$m(\text{NH}_3) = n(\text{NH}_3) \cdot M(\text{NH}_3) = 3.481 \cdot 10^{-4}(\text{mol}) \cdot 17.031 \left(\frac{\text{g}}{\text{mol}} \right) = 5.929 \cdot 10^{-3}(\text{g})$$

2) The formula to calculate the ppm of NH₃ in the air is:

$$(NH_3)_{ppm} = \frac{n(NH_3)}{n(air)} \cdot 10^6$$

The number of the moles of air can be calculated this way: first, we calculate the volume of air passed through HCl solution:

$$V_{air} = v \cdot t,$$

where v is the rate 10.0L/min, and t is the time, 10min.

$$V_{air} = 10 \left(\frac{L}{min} \right) \cdot 10(min) = 100L$$

Then, we can get the mass and number of the moles of air:

$$m_{air} = V_{air} \cdot d_{air} = 100(L) \cdot 1.20 \left(\frac{g}{L} \right) = 120 g$$

$$n_{air} = \frac{m_{air}}{M_{air}} = \frac{120(g)}{29.0 \left(\frac{g}{mol} \right)} = 4.14 mol$$

So then, ppm of ammonia is:

$$(NH_3)_{ppm} = \frac{n(NH_3)}{n(air)} \cdot 10^6 = \frac{3.481 \cdot 10^{-4}(mol)}{4.14 (mol)} \cdot 10^6 = 84 ppm$$

3) As 84ppm is > 50ppm, then the manufacturer is not in compliance with regulations.

Answer:

1) $5.929 \cdot 10^{-3}(g)$

2) 84 ppm

3) no, he is not.

<https://www.AssignmentExpert.com>