

20.

$$\Delta H^\circ = +93 \text{ kJ}$$

@ equilibrium at  $25^\circ\text{C}$

solid  $\text{NH}_4\text{HS}$  still in container

a) 2 pts

The equilibrium pressure of  $\text{NH}_3$  would be unaffected

$$K_p = (P_{\text{NH}_3}) (P_{\text{H}_2\text{S}})$$

The amount of solid  $\text{NH}_4\text{HS}$  present does not affect the equilibrium.

b) 2 pts

The equilibrium pressure of  $\text{NH}_3$  would decrease. In order for the pressure equilibrium constant,  $K_p$ , to remain constant, the equilibrium pressure of  $\text{NH}_3$  must decrease when the pressure of  $\text{H}_2\text{S}$  is increases.

c) 2 pts

The mass of  $\text{NH}_4\text{HS}$  increases. A decrease in volume causes the pressure of each gas to increase. To maintain the value of the pressure equilibrium constant,  $K_p$ , the pressure of each of the gases must decrease. That decrease is realized by the formation of more  $\text{NH}_4\text{HS}$  (a complete explanation of LeChatelier's Principle is also acceptable)

d) 2 pts

The mass of  $\text{NH}_4\text{HS}$  decreases because the endothermic reaction absorbs heat and goes nearer to completion (to the right) as the temperature increases.



a)  $\text{NH}_4\text{HS}$  @  $25^\circ\text{C}$

$$P_T = 0.659 \text{ atm @ equilibrium}$$

$$K_p = (P_{\text{NH}_3})(P_{\text{H}_2\text{S}})$$

$$P_{\text{NH}_3} = P_{\text{H}_2\text{S}} = \frac{0.659}{2} = 0.330 \text{ atm}$$

$$K_p = (0.330 \text{ atm})(0.330 \text{ atm}) = \boxed{0.109 \text{ atm}^2}$$

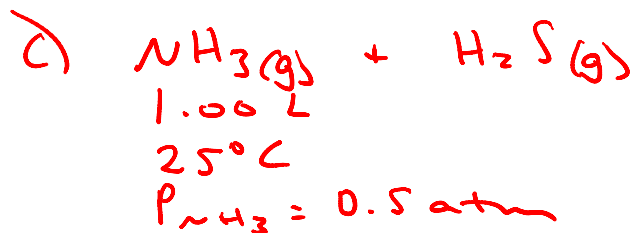
b) added  $\text{NH}_3$

at equilibrium  $P_{\text{NH}_3} = 2P_{\text{H}_2\text{S}}$

$$(2x)(x) = 0.109$$

$$\boxed{x = 0.233 \text{ atm} = P_{\text{H}_2\text{S}}}$$

$$\boxed{2x = 0.466 \text{ atm} = P_{\text{NH}_3}}$$



$P_{\text{H}_2\text{S}} = 0.5 \text{ atm}$

equilibrium

pressure of  $\text{NH}_3$  =  
 equilibrium pressure

$\text{H}_2\text{S} = 0.330 \text{ atm}$

$P_{\text{NH}_3}$  that has reacted =  $P_{\text{H}_2\text{S}}$   
 =  $0.500 \text{ atm} - 0.330 \text{ atm} =$

$n = \frac{PV}{RT} = \frac{(0.170 \text{ atm})(1.00 \text{ L})}{(0.0821 \frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}})(298\text{K})} = \frac{0.170 \text{ atm}}{6.95 \times 10^{-3} \text{ mol/L}}$



$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = 1.8 \times 10^{-5}$$

$$a) \quad 1.8 \times 10^{-5} = \frac{x^2}{0.150 - x} \quad \text{insignificant}$$

$$x = 1.64 \times 10^{-3} \text{ M} = [\text{OH}^-]$$

$$\% \text{ rule} \quad \frac{1.64 \times 10^{-3}}{0.150} \times 100 = 1.1\% \checkmark$$

$$\% \text{ dissociation} = 1.1\%$$

$$b) \quad [\text{NH}_4\text{Cl}] = \frac{0.0500 \text{ mole}}{0.100 \text{ L}} = 0.500 \text{ M}$$



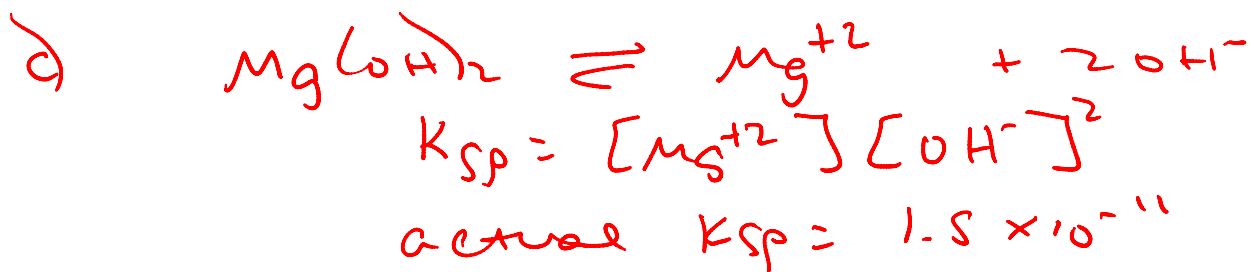
$$1.8 \times 10^{-5} = \frac{(0.500 + x)(x)}{(0.150 - x)}$$

$$x = 5.4 \times 10^{-6} \text{ M} = [\text{OH}^-]$$

$$\text{pOH} = -\log(5.4 \times 10^{-6}) = 5.27$$

$$14 - 5.27 = \boxed{8.73} = \text{pH}$$

$$\% \text{ rule} \quad \frac{5.4 \times 10^{-6}}{0.150} \times 100 = 0.0036\% \checkmark$$



$$[\text{MgCl}_2] = \frac{0.0800 \text{ mol}}{0.100 \text{ L}} = 0.800 \text{ M}$$



$$K_{sp} = (0.800)(5.4 \times 10^{-6})^2$$
$$2.3 \times 10^{-11}$$

larger than actual  $K_{sp}$

yes - ppt will form

23)

(a) two points

Calculated Mm (HA) too low

$M(\text{NaOH}) \Rightarrow V(\text{NaOH}) \Rightarrow n(\text{NaOH}) \Rightarrow n(\text{HA}) \Rightarrow Mm(\text{HA})$

$(M = n \div V)$  and  $(Mm = m \div n)$

(b) two points

Calculated Mm(HA) not affected

Any one of the following reasons. Water: does not change  $n(\text{HA})$

OR changes only

$M(\text{HA})$  -- sense of dilution OR is not a reactant

(c) two points

Calculated Mm(HA) too high

equivalence point  $\Rightarrow n(\text{NaOH}) \Rightarrow n(\text{HA}) \Rightarrow Mm(\text{HA})$  (expected pH higher)

Note: "no effect if NaOH standardized with same indicator" earns 2 points; no credit

earned if pH=7

or neutral

(d) two points

Calculated Mm(HA) too low

$V(\text{NaOH}) \Rightarrow n(\text{NaOH}) \Rightarrow n(\text{HA}) \Rightarrow Mm(\text{HA})$

Note: point earned for  $V(\text{NaOH})$  only if:

(i) no explanation point is earned in (a)

(ii) explanation in (a) also includes  $V(\text{NaOH})$