Show your work. Write your answer in the indicated space. 10% of each problem will be deducted if you have the incorrect number of significant figures. Useful constants: ln(10) = 2.303, R = 8.314 J/(mol·K).

1. The insoluble salt AgBr can be dissolved in ammonia solution according to the equilibrium below. What concentration of NH$_3$ is needed to dissolve 0.010 mol of AgBr in 1.0 L of solution? (30 points)

\[
\text{AgBr}(s) + 2\text{NH}_3 \rightleftharpoons [\text{Ag(NH}_3)_2]^+ + \text{Br}^- \quad K = 8.0 \times 10^{-6}
\]

init. \( x \) 0 0 let \( x \) = initial conc. of NH$_3$

\[\Delta \quad -0.020 +0.01 +0.01\]

final \( x - 0.020 \) 0.01 0.01 (final conc. of \([\text{Ag(NH}_3)_2]^+\) must be 0.010 M

\[
K = \frac{[\text{Ag(NH}_3)_2]^+[\text{Br}^-]}{[\text{NH}_3]^2}; \quad 8.0 \times 10^{-6} = \frac{(0.010)(0.010)}{(x - 0.020)^2}
\]

The right side is a perfect square, so take the square root: 
\[2.8 \times 10^{-3} = (0.010)/(x - 0.020)\]

\[x - 0.020 = (0.010)/(2.8 \times 10^{-3}) = 3.5; \quad x = 3.5 + 0.020 = 3.5 \text{ M NH}_3\]

2. Write below the chemical condition used to precipitate Group III metal cations. (30 points)

Adjust the pH to 8 with NH$_3$ and saturate the solution with H$_2$S. The base insoluble sulfides and hydroxides precipitate.

3. Calculate \( K_p \) for the following equilibrium. \( \Delta G^\circ_f(\text{HI}) = +1.3 \text{ kJ/mol} \) (40 points)

\[
\text{H}_2(g) + \text{I}_2(s) \rightleftharpoons 2\text{HI}(g) \quad \Delta G^\circ = 2\Delta G^\circ_f(\text{HI}) = 2(1300 \text{ J/mol}) = 2600 \text{ J}
\]

\[
\Delta G^\circ = -2.303RT \log(K_p); \quad 2600 \text{ J} = (2.303)(8.314)(298 \text{ K})\log(K_p)
\]

\[
\log(K_p) = -0.46; \quad K_p = 10^{-0.46} = 0.35
\]