1. (3 Pts) Write the expressions for both $K_c$ and $K_p$ for the reaction

$$\text{PH}_3\text{BCl}_3(s) \rightleftharpoons \text{PH}_3(g) + \text{BCl}_3(g)$$

$$K_c = \frac{[\text{PH}_3][\text{BCl}_3]}{[\text{PH}_3\text{BCl}_3]}$$

$$K_p = P_{\text{PH}_3} P_{\text{BCl}_3}$$

2. (6 Pts) At a high temperature, the following reaction has an equilibrium constant of $1.0 \times 10^3$.

$$\text{H}_2(g) + \text{F}_2(g) \rightleftharpoons 2\text{HF}(g)$$

If 1.00 mol of each of H$_2$ and F$_2$ are allowed to come to equilibrium in a 10.0 L vessel, calculate the equilibrium concentration of H$_2$ and HF and then determine how many moles of each element or compound are present at equilibrium.

$$K_c = \frac{[\text{HF}]^2}{[\text{H}_2][\text{F}_2]}$$

$$1.0 \times 10^3 = \frac{(2x)^2}{(0.100-x)(0.100-x)}$$

$$x = 0.083$$

$$\text{Volume} = 10.0 \text{ L}$$

3. (6 Pts) When 0.152 mol of solid PH$_3$BCl$_3$ is introduced into a 3.0 L container at a certain temperature, 8.44 $\times$ 10$^{-3}$ mol of PH$_3$ is present at equilibrium.

$$\text{PH}_3\text{BCl}_3(s) \rightleftharpoons \text{PH}_3(g) + \text{BCl}_3(g)$$

Construct a reaction table (I.C.E.) for the process, and use it to calculate $K_c$ at this temperature.

$$K_c = \frac{[\text{PH}_3][\text{BCl}_3]}{[\text{PH}_3\text{BCl}_3]}$$

$$K_c = \frac{(8.44 \times 10^{-3})(3.0)}{8.44 \times 10^{-3}}$$

$$x = \frac{8.44 \times 10^{-3}}{3.0}$$

$$K_c = 7.91 \times 10^{-6}$$

********** THERE ARE MORE QUESTIONS ON THE BACK **********
4. (6 Pts) Consider the following gas-phase equilibrium reaction:

\[ \text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) \]

If 1.0 mol of NO is introduced into a 1.0 L container at 2000°C, what is the concentration of NO when equilibrium is reached?

\[
K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}
\]

I. \[ \text{C.O.} \]
C. \[ +x \quad +x \quad 1.0 - 2x \]
E. \[ x \quad x \]

\[
4.1 \times 10^{-4} = \frac{(1.0 - 2x)^2}{1.0 - 2x}
\]

\[
\sqrt{4.1 \times 10^{-4}} = \frac{1.0 - 2x}{x}
\]

\[
0.0202x = 1.0 - 2x
\]

\[
2.02025x = 1.0
\]

\[
x = 0.4950
\]

\[
1.0 - 2(0.4950) = 0.010\text{ M}
\]

5. (4 Pts) Consider the equilibrium:

\[ \text{A(s)} \rightleftharpoons \text{B(s)} + \text{C(g)}; \Delta H_{\text{vap}} > 0 \]

Predict and explain how or whether the following actions would affect this equilibrium.

a. adding more solid A

No effect (solids do not affect \( \Delta H \))

b. lowering the temperature

More A (since \( \Delta H \) is endothermic, heat is a reactant)

c. increasing the pressure on the system by reducing its volume

More A (since conc. of C(g) increases)

d. adding helium gas to increase the total pressure

No effect (the partial pressure of C(g) does not change).