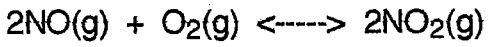
Ch 12 **EQUILIBRIUM CALCULATIONS** Name_____

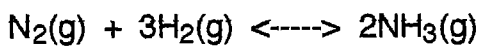
In solving the following problems
- write the equilibrium expression
- convert moles and litres to concentration
- omit the units for $K_{eq}$ but write them for all other quantities

1. A closed container is found to have 0.45 M NO(g), 0.78 M $O_2$(g), and 0.26 M $NO_2$(g). Determine the equilibrium constant for the following equilibrium:



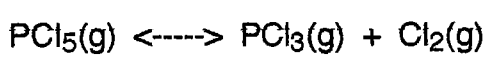
$$2NO(g) + O_2(g) \text{ <-----> } 2NO_2(g)$$

2. A 1.00 L bulb holds 1.22 mol $NH_3$(g), 2.46 mol $H_2$(g), and 1.80 mol $N_2$(g). Calculate the $K_{eq}$ for the following equilibrium:



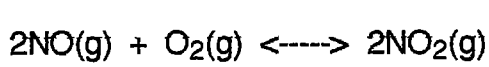
$$N_2(g) + 3H_2(g) \text{ <-----> } 2NH_3(g)$$

3. A 2.50 L container holds 1.65 moles $PCl_5$(g), 0.575 moles $PCl_3$(g), and 1.55 moles $Cl_2$(g). Calculate the $K_{eq}$ for the following equilibrium:



$$PCl_5(g) \text{ <-----> } PCl_3(g) + Cl_2(g)$$

4. A 5.00 L container is found to hold 0.340 moles NO(g), 0.950 moles $O_2$(g), and 0.505 moles $NO_2$(g). Determine the equilibrium constant for the following equilibrium:



$$2NO(g) + O_2(g) \text{ <-----> } 2NO_2(g)$$

5. A closed container is found to have 1.4 M $NH_3(g)$, 0.88 M $O_2(g)$, 0.72 M $H_2O(g)$ and 0.46 M $NO(g)$. Determine the equilibrium constant for the following equilibrium:

$$6H_2O(g) + 4NO(g) \text{ <-----> } 4NH_3(g) + 5O_2(g)$$

6. The $K_{eq}$ for $N_2(g) + 3H_2(g)$ <-----> $2NH_3(g)$ is 4.68 at a certain temperature. If the $[N_2(g)] = 0.465$ M and the $[H_2(g)] = 0.892$ M at this temperature, what is the $[NH_3(g)]$?

7. The $K_{eq}$ for the equilibrium $3O_2(g)$ <-----> $2O_3(g)$ is determined to be 0.444 at a certain temperature. If the $[O_3(g)] = 0.246$ M, what is the $[O_2(g)]$ at this temperature?

8. The $K_{eq}$ for the equilibrium $2NOCl(g)$ <-----> $2NO(g) + Cl_2(g)$ is found to be 9.00 at a certain temperature. A 4.00 L container is found to have 2.40 M $NOCl(g)$ and 1.60 M $NO(g)$. How many moles of $Cl_2(g)$ will be in the container?

9. The $K_{eq}$ for the equilibrium $2NO(g) + O_2(g)$ <-----> $2NO_2(g)$ is found to be 2.00 at a certain temperature. A 3.50 L container is found to have 1.34 M $NO(g)$ and 1.80 M $NO_2(g)$. How many moles of $O_2(g)$ will be in the container?

10. A 1.00 L reaction vessel has 0.654 moles of NOCl(g) placed in it. After equilibrium is achieved according to the equation $2NOCl(g) \text{ <-----> } 2NO(g) + Cl_2(g)$ , the concentration of $Cl_2(g)$ is found to be 0.168 M. Determine the $K_{eq}$ for this reaction.

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11. When 1.42 mol $N_2(g)$ and 2.86 mol $H_2(g)$ are introduced to a 1.00 L container and allowed to reach equilibrium, 0.98 mol $N_2(g)$ are found. What is the $K_{eq}$ for the equilibrium $N_2(g) + 3H_2(g) \text{ <-----> } 2NH_3(g)$ ?

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12. A bulb has 0.345 M CO(g) and 0.500 M $H_2O(g)$ placed in it. After 25 min, equilibrium has been reached according to the equation $CO(g) + H_2O(g) \text{ <-----> } CO_2(g) + H_2(g)$ . Analysis shows the $[CO_2(g)]$ is now 0.122 M. Calculate $K_{eq}$ for this equilibrium.

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13. A 4.00 L container was initially filled with 2.44 moles of $O_2(g)$ and 2.68 moles of $SO_2(g)$. At equilibrium, 1.32 moles of $SO_3(g)$ are found. Determine the $K_{eq}$ for the equilibrium $2SO_2(g) + O_2(g) \text{ <-----> } 2SO_3(g)$ .

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14. The $K_{eq}$ for the equilibrium $SO_3(g) + NO(g) <-----> SO_2(g) + NO_2(g)$ is 2.46 at a certain temperature. If 2.44 moles of $SO_3(g)$ and 2.44 moles of NO(g) are placed in a 1.00 L flask at this temperature and allowed to reach equilibrium, what will the equilibrium concentrations be?

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15. If 2.40 mol HF(g) are placed in a 2.00 L container and allowed to reach equilibrium according to the equation $2HF(g) <-----> H_2(g) + F_2(g)$ , what will the equilibrium concentration of each of the species be? The $K_{eq}$ for the reaction is 0.666.

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16. The $K_{eq}$ for the equilibrium $CO(g) + H_2O(g) <-----> CO_2(g) + H_2(g)$ is 1.28 at a certain temperature. When 2.00 mole each of CO(g) and $H_2O(g)$ are placed in a 1.00 L flask and allowed to achieve equilibrium at this temperature, what are all of the final concentrations?

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17. When 4.22 mol $H_2(g)$ and 4.22 mol $Cl_2(g)$ are injected into a 1.00 L container and achieve equilibrium according to the equation $H_2(g) + Cl_2(g) <-----> 2HCl(g)$ , what are the new concentrations? The $K_{eq}$ is known to be 0.888.

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18. The Keq for the equilibrium $2NO(g) + O_2(g) <-----> 2NO_2(g)$ is known to be 12.6 at a certain temperature. If, at this temperature, 2.46 mol NO(g), 1.23 mol $O_2(g)$, and 9.86 mol $NO_2(g)$ are introduced into a 1.00 L container, which way will the reaction proceed in order to achieve equilibrium?

19. A 3.00 L container has 0.576 moles $NH_3(g)$, 0.843 moles $H_2(g)$, and 0.972 moles $N_2(g)$ added to it. As it approaches equilibrium according to $N_2(g) + 3H_2(g) <-----> 2NH_3(g)$, will the reaction proceed in the forward direction or the reverse direction? The $K_{eq}$ for the reaction is 7.57.

20. The $K_{eq}$ for the reaction $CO(g) + H_2O(g) <-----> CO_2(g) + H_2(g)$ is 1.24. If the initial conditions are: [CO(g] = 0.678 M, $[H_2O(g)]$ = 0.456 M, $[CO_2(g)]$ = 0.961 M, and $[H_2(g)]$ = 0.543 M, will the [CO(g)] increase or decrease as the reaction proceeds toward equilibrium?

21. A 1.00 L bulb is injected with 0.87 mol $SO_2(g)$, 0.12 mol $O_2(g)$, and 0.59 mol $SO_3(g)$. As the reaction $2SO_3(g) <-----> 2SO_2(g) + O_2(g)$ proceeds towards equilibrium, will the $[O_2(g)]$ increase or decrease? The $K_{eq}$ for the equilibrium is 0.41.