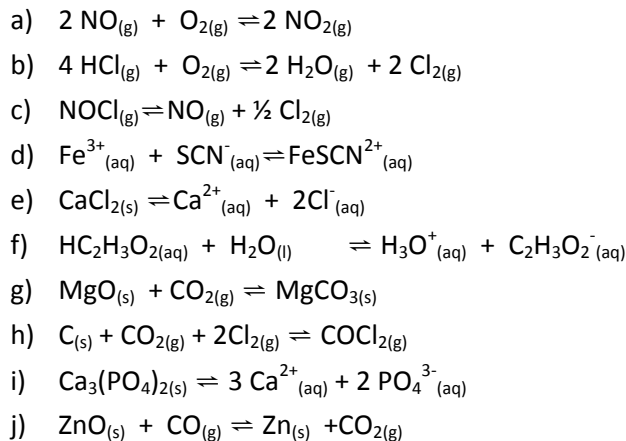


Equilibrium Worksheet

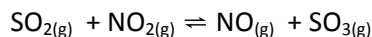
Complete the following questions on a separate piece of paper.

1. Write the equilibrium expression, K_{eq} , for each of the following reactions:



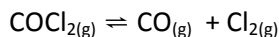
2. The equilibrium constant for the equilibrium $\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{2(g)} + \text{H}_{2(g)}$ is 302 at 600K. What is the value of the equilibrium constant for the reverse reaction at the same temperature?
3. Classify the following equilibria as heterogeneous or homogeneous, and write an equilibrium expression for each.
- a) $\text{NH}_4\text{NO}_{2(s)} \rightleftharpoons \text{N}_{2(g)} + 2 \text{H}_2\text{O}_{(g)}$
b) $\text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_2\text{O}_{(g)}$
c) $\text{SO}_{2(g)} + \frac{1}{2} \text{O}_{2(g)} \rightleftharpoons \text{SO}_{3(g)}$
d) $\text{S}_{8(s)} + 8 \text{O}_{2(g)} \rightleftharpoons 8 \text{SO}_{2(g)}$
4. At the equilibrium point in the decomposition of phosphorus pentachloride to chlorine and phosphorus trichloride, the following concentrations are obtained: 0.010 mol/L PCl_5 , 0.15 mol/L PCl_3 and 0.37 mol/L Cl_2 . Determine the K_{eq} for the reaction. [5.55]
5. The colourless gas dinitrogen tetroxide decomposes to the brown coloured air pollutant nitrogen dioxide and exists in equilibrium. A 0.125 mol sample of dinitrogen tetroxide is introduced into a 1.00 L container and allowed to decompose at a given temperature. When equilibrium is reached, the concentration of the dinitrogen tetroxide is 0.0750 mol/L. What is the value of K_{eq} for this reaction? [0.13]
6. Phosphorus pentachloride decomposes to phosphorus trichloride and chlorine gas. A 1.10 mol/L sample of PCl_5 was placed into a vessel. At equilibrium it was determined that the concentration was 0.33 mol/L. Calculate the K_{eq} for this reaction. [1.80]
7. Gaseous dinitrogen tetroxide is placed in a flask and allowed to decompose to nitrogen dioxide and reach equilibrium at 100°C. At 100°C, the value of K_{eq} is 0.212. If the concentration of dinitrogen tetroxide at equilibrium is 0.155 mol/L, what is the concentration of nitrogen dioxide at equilibrium? [0.181 M]
8. A 0.921 mol sample of dinitrogen tetroxide is placed in a 1.00 L vessel and heated to 100°C. At equilibrium it is found that 20.7 % of the dinitrogen tetroxide has decomposed to nitrogen dioxide. Calculate the K_{eq} for this reaction. [0.200]
9. At 245°C, the equilibrium concentration of dinitrogen tetroxide gas is 6.38×10^{-3} mol/L and the total gas concentration is 1.23×10^{-2} mol/L. Determine the K_{eq} for the decomposition of dinitrogen tetroxide gas to nitrogen dioxide gas at this temperature. [5.49×10^{-3}]

10. The following reaction has K_{eq} value of 85.0 at 460°C:



If a mixture of sulfur dioxide and nitrogen dioxide is prepared, each with an initial concentration of 0.100 mol/L, calculate the equilibrium concentrations of nitrogen dioxide and nitrogen monoxide at this temperature.
[NO₂=9.8x10⁻³ M, NO=0.0902 M]

11. At 100°C the reaction below has an equilibrium constant, K_{eq} , value of 2.2x10⁻¹⁰. If 1.00 mol of phosgene, COCl₂, is placed in a 10.0 L flask, calculate the concentration of carbon monoxide at equilibrium. [4.7x10⁻⁶]



12. Six moles of SO_{2(g)} and four moles of O_{2(g)} are introduced into a 1.00 L reaction vessel and allowed to react to form SO_{3(g)}. At equilibrium, the vessel contains four moles of SO_{3(g)}. Calculate K_{eq} for this reaction. [2.00]

13. Hydrogen and iodine gases react to form hydrogen iodide gas. If 6.00 mol of H₂ and 3.00 mol of I₂ are placed in a 3.00 L vessel and allowed to come to equilibrium at 250°C calculate the equilibrium concentrations of all species. The K_{eq} for the reaction is 4.00 at 250 °C.
[H₂=1.33 M, I₂=0.330 M, HI=1.33 M]

14. At 375°C, the equilibrium constant for the reaction between hydrogen and iodine gases to make hydrogen iodide gas is 51.5. A sample of hydrogen iodide was placed into a 2.00 L vessel and it was found that at equilibrium 0.218 mol of H₂ gas was present.

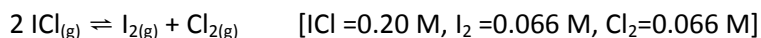
- a) How many moles of HI were originally placed into the flask? [2.00 mol]
b) What are the equilibrium concentrations of I₂ and HI? [I₂=0.109 M and HI=0.782 M]

15. Carbon monoxide and chlorine gases react to form phosgene gas (COCl₂). At equilibrium, there is 0.62 mol of CO, 0.28 mol of Cl₂ and 1.56 mol of COCl₂ in a 2.00 L container. How many moles of Cl₂ must be added to reduce the concentration of CO to 0.25 mol/L? [0.22 mol]

16. At 350°C the equilibrium constant for the reaction $\text{CaCO}_{3(s)} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_{2(g)}$ was found to be 0.15.

- a) What is the equilibrium concentration of carbon dioxide at this temperature? [0.15 M]
b) If 100.0 g of solid calcium carbonate was placed in a 10.0 L vessel and heated to the same temperature could equilibrium be reached? Justify your answer with calculations. [no]

17. The equilibrium constant for the reaction below is 0.11. Calculate all equilibrium concentrations if 0.33 mol of iodine chloride gas is placed in a 1.00 L vessel and allowed to come to equilibrium.



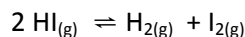
18. At 1200°C, the value of K_{eq} for the formation of hydrogen chloride gas from its elements is 2.51x10⁴. Determine the equilibrium concentrations of all species if 0.250 mol of both chlorine gas and hydrogen gas are placed in a 1.00 L vessel and allowed to reach equilibrium. [H₂=3.00x10⁻³ M, Cl₂=3.00x10⁻³ M, HCl =0.494 M]

19. Nitrogen gas reacts with oxygen gas to form nitrogen monoxide gas. The K_{eq} for this reaction at 1530°C is 1.20x10⁻⁴. Determine the equilibrium concentrations of all species when 1.00 mol/L of nitrogen and oxygen is placed in a vessel and allowed to reach equilibrium. [N₂ =0.995 M, O₂=0.995 M, NO =0.0110 M]

20. At 2000°C, the K_{eq} value for the decomposition of carbon dioxide gas to carbon monoxide and oxygen gases is 6.40x10⁻⁷. Determine the oxygen concentration at equilibrium when 1.00 mol of CO₂ is placed in a 1.00 L vessel. [5.43x10⁻³ M]

21. The dissociation of ammonia gas to nitrogen and hydrogen gases has a K_{eq} value of 2.63x10⁻⁹ at 27°C. If 2.00 mol of ammonia is placed in a 2.00 L vessel and allowed to reach equilibrium, what is the concentration of hydrogen and nitrogen.
[N₂ =3.14x10⁻³ M, H₂=9.42x10⁻³ M]

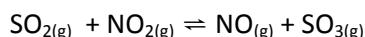
22. The following reaction takes place in a 1.00L vessel at 500°C.



Equilibrium concentrations were found to be 1.76 mol/L HI, 0.200 mol/L H₂ and 0.200 mol/L I₂. If an additional 0.500 mol of hydrogen iodide gas is introduced at the same temperature, what the new concentrations of all gases once equilibrium has been reestablished? [HI= 2.04 M, H₂=0.308, I₂=0.308M]

23. The dissociation of ammonia gas to nitrogen and hydrogen gases at 400.0°C has a K_{eq} value of 1.92. If 0.500 mol of ammonia is placed in a 500.0 mL container, determine the equilibrium concentrations of all gases. [NH₃=0.37 M, H₂=0.945, N₂=0.315M]

24. The equilibrium constant, K_{eq} for the reaction below is 85.0 at 460°C. If a mixture is prepared where the initial concentration of sulfur dioxide is 1.00 mol/L and nitrogen dioxide is 2.00 mol/L calculate the equilibrium concentration of nitrogen monoxide and nitrogen dioxide. [NO=0.989 M, NO₂=1.01 M]

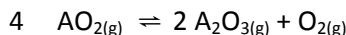


25. Hydrogen gas reacts with iodine vapour to produce hydrogen iodide vapour. The value of K_{eq} is 49.0. Calculate the concentration of all species at equilibrium, if there was 2.00 mol of hydrogen and 0.500 mol of iodine in a one vessel initially. [H₂=1.51 M, I₂=0.0130M, HI=0.974 M]

26. In a 1 L vessel, 3.0 g of phosphorus pentachloride gas is heated. Only, 30 % of the phosphorus pentachloride dissociates into phosphorus trichloride and chlorine gases. What is the density of the equilibrium mixture?

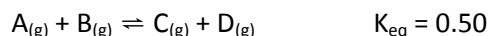
27. Phosphorus pentachloride gas decomposes into phosphorus trichloride and chlorine gases. If 13.9 % of a 1.0 mol/L concentration of phosphorus pentachloride decomposes, find the value of K_{eq}. [2.24 x 10⁻²]

28. The substance AO₂ is 10.0 % molar dissociated according to the following reaction.



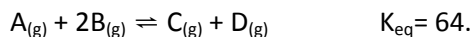
Find the equilibrium concentration of each species if 2.0 mol of A₂O₃ and 1.0 mol of O₂ are initially present in a 1.0 L volume. [AO₂=3.6 M, A₂O₃=0.20 M, O₂=0.10 M]

29. If 0.70 mol of A, 0.50 mol of B, 0.40 mol of C and 0.90 mol of D were placed in 1.0 L container and allowed to come to equilibrium according to the following equation.



Calculate the equilibrium concentrations of all species. [A=0.80 M, B=0.60 M, C=0.30 M, D=0.80 M]

30. An equimolar concentration of A and B plus 2.00 mol of both C and D were placed in a 1.00 L vessel.



Given that the equilibrium concentration of A is 1.00 M, calculate:

- a) The equilibrium concentrations of all species. [A=1.00 M, B=0.334 M, C=2.67 M, D=2.67M]
b) The initial concentrations of A and B. [1.67 M]

31. The K_{eq} value for the formation of sulphur trioxide gas from sulphur dioxide and oxygen gases is 4.5. If the equilibrium concentration of oxygen was 2.0 M, determine the number of moles of sulfur trioxide originally present in a 1.0 L vessel. [16 mol]

If you need more you can complete the following questions from your textbook: 438 # 8, 9, page 472 # 5, 6, page 480 # 9, 10, page 481 # 1-8.