

SCH4U 4-2F: Equilibrium Constants
(49 marks)

Knowledge/Understanding (K/U)	Thinking/Inquiry (T/I)	Application (A)	Communication I
/9	/33	/7	

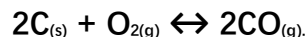
PART A: Defining Equilibrium Constants**[Total K: 9 marks]**

Answer each of the following questions using at least 2 chemistry terms.

- Define** the equilibrium constant. **Explain** what the equilibrium constant represents. State the equation used to calculate the equilibrium constant. [K: 2 marks]
- State** the difference between K and Q. **Explain** why K is calculated. **Describe** what information K can provide about a chemical reaction. [K: 3 marks]
- For each of the equilibrium constant values below, **describe** the system in terms of equilibrium, reactants, and products: [K: 4 marks]
 - Zero:
 - Approaching Infinity:
 - 0.01:
 - 100:

PART B: Chemistry is Everywhere: The burning of Coal**[Total: A: 7 marks]**

1. The burning of coal (pure carbon) for energy is used extensively throughout the world. Unfortunately, it can also be converted to carbon monoxide. Carbon monoxide can lead to death through asphyxiation. The equilibrium system for coal combustion is:



The equilibrium constant for this reaction at 25⁰C is 1.6×10^{-2} .

The equilibrium constant for this reaction at 1000⁰C is 1.7×10^2 .

- a) **Evaluate** whether it would be better to burn coal at the high temperature or the low temperature. **Justify** your decision by **comparing** the magnitude of K and the production of carbon monoxide at each temperature and by **analysing** the potential impact on human health.

[A: 4 marks]

- b) **Predict** whether or not the combustion of coal is an exothermic or endothermic reaction. **Justify** your answer using the equilibrium constants and your knowledge of equilibrium.

[A: 2 marks]



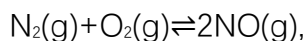
c) **Write** an equilibrium constant expression for the combustion of coal.

[A: 1 mark]

PART C: Equilibrium Constant Calculations

[Total: T: 33 marks]

1. Nitrogen oxides are air pollutants produced by the reaction of nitrogen and oxygen at high temperatures. At 2000 °C, the value of the K_c for the reaction,



is 4.1×10^{-4} . **Calculate** the equilibrium concentration of $\text{N}_2(\text{g})$ in air at 1 atm pressure and 2000 °C. Show your work. The equilibrium concentrations of NO and O_2 at this pressure and temperature are 3.6×10^{-4} M and 0.0089 M, respectively.

[T: 4 marks]



2. The following reaction run at temperature of 303.15 K produces phosphorous trichloride gas and chlorine gas.



At equilibrium, analysis shows concentrations of $3.35 \times 10^{-3} \text{ M}$ of $\text{PCl}_{5(g)}$ and 0.150 M of $\text{PCl}_{3(g)}$.

Calculate the concentration of $\text{Cl}_{2(g)}$ at equilibrium. Show your work. [T: 4 marks]



3. At 423 K, 0.25 mol of iodine gas and 0.25 mol of bromine gas are placed in a closed 5.0-L container and allowed to reach equilibrium.



Calculate the equilibrium concentration of $\text{IBr}_{(g)}$. Show your work.

[T: 5 marks]



4. At 25°C, 0.75 mol of $\text{ICl}_{(g)}$ is placed in a 5-L container and allowed to reach equilibrium.

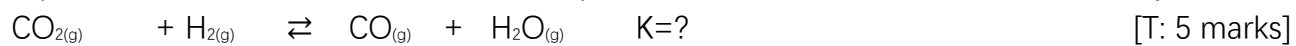


Calculate the equilibrium concentrations of both reactants and products. Show your work.

[T: 5 marks]

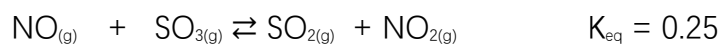


5. Initially, 3.75 mol of carbon dioxide gas and 2.25 mol of hydrogen gas are placed in a 2.50-L container and an equilibrium is established. The concentration of carbon monoxide at equilibrium is 0.6 mol/L. **Calculate** the equilibrium constant for this reaction. Show your work.





6. In a container, sulfur trioxide and nitrogen monoxide react to produce sulfur dioxide and nitrogen dioxide. At a certain temperature, the equilibrium constant for this reaction is 0.25.



At one point in the reaction the concentrations are: $[\text{NO}_{(g)}] = 3.00 \text{ mol/L}$, $[\text{SO}_{3(g)}] = 3.00 \text{ mol/L}$, $[\text{SO}_{2(g)}] = 2.00 \text{ mol/L}$, and $[\text{NO}_{2(g)}] = 2.00 \text{ mol/L}$.

- a) Prove that the system above has not reached equilibrium through calculation. Show your work. [T: 4 marks]

- b) **Identify** the direction in which the system will proceed to establish equilibrium. [T: 1 mark]

- c) **Calculate** the equilibrium concentrations of all the reactants and products in this reaction. Show your work. [T: 5 marks]