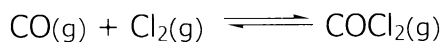


Unless otherwise specified, each question is worth 4 points.

1. Carbonyl chloride (COCl_2), also called phosgene, is a highly poisonous gas that was used on the battlefield in World War I. It is produced by the reaction of carbon monoxide with chlorine gas:



In an experiment conducted at 74°C , the equilibrium concentrations of the species involved in the reaction were as follows: $[\text{CO}] = 1.2 \times 10^{-2} \text{ M}$, $[\text{Cl}_2] = 0.054 \text{ M}$, and $[\text{COCl}_2] = 0.14 \text{ M}$.

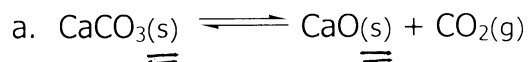
- a. Write the equilibrium expression for K_c .

$$K = \frac{[\text{COCl}_2]^2}{[\text{CO}][\text{Cl}_2]}$$

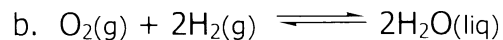
- b. Determine the value of the equilibrium constant.

$$K = \frac{(0.14)}{(1.2 \times 10^{-2})(0.054)} = 216 \quad \boxed{220}$$

2. Write equilibrium expressions for each of the following reactions: (2 points each)



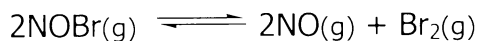
$$K_c = [\text{CO}_2]$$



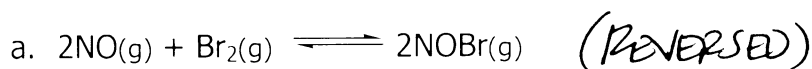
$$K_c = \frac{1}{[\text{O}_2][\text{H}_2]^2}$$

Unless otherwise specified, each question is worth 4 points.

3. The following reaction has an equilibrium constant, K_c , equal to 0.014 at 100°C.



Determine the value of K_c for each of the following reactions at 100°C:

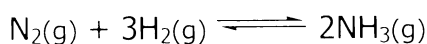


$$K = \frac{1}{0.014} = \boxed{71}$$



$$(\times 2) \quad K = (0.014)^2 = \boxed{2.0 \times 10^{-4}}$$

4. At 375°C, the equilibrium constant for the following reaction is 1.2



At the start of the reaction, the concentrations of N_2 , H_2 and NH_3 are 0.071 M, 0.0092 M, and 1.83×10^{-4} M, respectively.

- a. Calculate Q for this system at the start of the reaction.

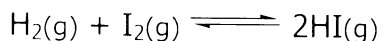
$$Q = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{(1.83 \times 10^{-4})^2}{(0.071)(0.0092)^3} = \frac{3.35 \times 10^{-8}}{(0.071)(7.79 \times 10^{-7})} = \boxed{0.61}$$

- b. Is this system at equilibrium? If this system is not at equilibrium, which direction will it proceed (or "shift") to establish equilibrium.

$\boxed{\text{NO.} \rightarrow}$

Unless otherwise specified, each question is worth 4 points.

5. K_c for the reaction of hydrogen and iodine to produce hydrogen iodide,



is 54.3 at 430°C. What will the concentrations be at equilibrium if we start with 0.240 M concentrations of both H_2 and I_2 ?

$$\text{INITIAL:} \quad \frac{\text{H}_2}{0.240\text{M}} \quad \frac{\text{I}_2}{0.240\text{M}} \quad \frac{\text{HI}}{\emptyset} \quad (Q = \emptyset)$$

REACT	-x	-x	(→) +2x
EQUIL	0.240-x	0.240-x	2x

$$K = 54.3 = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{(2x)^2}{(0.240-x)(0.240-x)}$$

$$54.3 = \frac{4x^2}{(0.240-x)^2}$$

$$\sqrt{54.3} = \frac{2x}{0.240-x}$$

$$7.37 = \frac{2x}{0.240-x}$$

$$1.77x - 7.37x = 2x \quad x = 0.189$$

$$[\text{H}_2] = [\text{I}_2] = 0.240 - 0.189 = \boxed{0.051\text{M}}$$

$$[\text{HI}] = 2x = \boxed{0.378\text{M}}$$