answers

1. Several reaction mixtures containing only N_2O_4 and NO_2 were allowed to come to equilibrium at 25 °C. The equilibrium concentrations of the species in each experiment are as follows:

Exp #	$[N_2O_4]_{eq}$ (M)	$[NO_2]_{eq}$ (M)
1	0.5307	0.0495
2	1.114	0.0717
3	0.7456	0.0587
4	0.679	0.056

What is the equilibrium constant for the following reaction? Show that the same value for K_{eq} is obtained from each of the experiments.

$$N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$$

for this reaction, $K_{eq} = \dfrac{[NO_2]^2}{[N_2O_4]}$

exp 1 $K_{eq} = \dfrac{(0.0495)^2}{0.5307} = 0.00462$

exp 2 $K_{eq} = \dfrac{(0.0717)^2}{(1.114)} = 0.00461$

exp 3 $K_{eq} = \dfrac{(0.0587)^2}{0.7456} = 0.00462$

exp 4 $K_{eq} = \dfrac{(0.056)^2}{0.679} = 0.00462$

The value of the equilibrium constant doesn't depend on the specific concentrations but the equation will always be satisfied.

Use 0.00462 for the problems on the next page.

*** Check with Dr. Fantini that you have the right value for question 1 before continuing. ***

2. What is the equilibrium constant for the following equation at 25 °C?

(call this reaction # 2) $2\ NO_2(g) \rightleftharpoons N_2O_4(g)$ → $K_{eq,2} = \dfrac{[N_2O_4]}{[NO_2]^2}$

for $N_2O_4(g) \rightleftharpoons 2\ NO_2$ (prev. page), $K_{eq} = 0.00462$

This reaction is the same reaction, but reversed.

for this rxn, $K_{eq,2} = \dfrac{1}{0.00462} = 216.5$ because $K_{eq,2} = \dfrac{1}{K_{eq,1}}$

3. What is the equilibrium constant for the following equation at 25 °C?

(call this reaction # 3) $NO_2(g) \rightleftharpoons {}^1/_2\ N_2O_4(g)$

$K_{eq,3} = \dfrac{[N_2O_4]^{1/2}}{[NO_2]}$

Note the equation is like the the one above, except all the coefficients have been divided through by 2.

note $K_{eq,3} = (K_{eq,2})^{1/2} = \left(\dfrac{[N_2O_4]}{[NO_2]^2}\right)^{1/2}$ so $K_{eq,3} = \sqrt{216.5}$

$K_{eq,3} = 14.7$

4. For a mixture of N_2O_4 and NO_2 that is known to be at equilibrium at 25 °C, only the $[NO_2]$ was measured. What is $[N_2O_4]$ at equilibrium if the $[NO_2] = 0.0098$ M?

you can do this building off any of the questions above. Using the expressions from question 1:

$N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$ $K_{eq} = 0.00462$

$[N_2O_4]_{eq} = ?$ $[NO_2]_{eq} = 0.0098\ M$

$K_{eq} = 0.00462 = \dfrac{(0.0098)^2}{[N_2O_4]_{eq}}$ ⇒ $[N_2O_4]_{eq} = \dfrac{(0.0098)^2}{0.00462}$

$[N_2O_4]_{eq} = 0.021\ M$