# UNIT 5

# EQUILIBRIUM

# ANSWERS

## Equilibrium Problems

## Solutions

1.

| | $\Delta H$ + | $N_2O_4$ ⇌ | $2NO_2$ |
|---|---|---|---|
| initial | | ? | ? |
| Equilibrium | | 1.15 | 2 |

$$K_{eq} = \frac{[NO_2]^2}{[N_2O_4]} = \frac{2^2}{1.15} = \frac{4}{1.15} = 3.478\ mol/L$$

∴ The equilibrium constant is 3.478 mol/L

2. a) An increase in pressure will force the system to the left
b) An increase in temperature will force the system to the right.
c) An addition of a catalyst will have no change.

3.

$$H_2 + I_2 \rightleftharpoons 2HI$$

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = 64 = \frac{x^2}{(0.2)^2}$$

$$x^2 = 2.56$$

$$x = 1.6\ mol/L$$

4.

$$2NO + O_2 \rightleftharpoons 2NO_2$$

$$K_{eq} = \frac{[NO_2]^2}{[NO]^2[O_2]} = 6.45 \times 10^5 = \frac{(0.19)^2}{x^2(0.606)}$$

$$x^2 = \frac{(0.19)^2}{(6.45 \times 10^5)(0.606)}$$

$$x^2 = 9.236 \times 10^{-8}$$

$$x = 3.04 \times 10^{-4}\ moles$$

5. a)

| | $H_2$ | + $CO_2$ | ⇌ $H_2O$ | + $CO$ |
|---|---|---|---|---|
| Initial | 0.5 | 0.5 | 0.5 | 0.5 |
| Equilibrium | 0.5-x | 0.5-x | 0.5+x | 0.5+x |

$$K_{eq} = 1.6 = \frac{(0.5+x)^2}{(0.5-x)^2}$$

$$1.265 = \frac{0.5+x}{0.5-x}$$

$$0.6325 - 1.265x = 0.5 + x$$

$$x = 0.058$$

$[H_2] = 0.5 - 0.058 = 0.44$

$[CO_2] = 0.5 - 0.058 = 0.44$

$[H_2O] = 0.5 + 0.058 = 0.56$

$[CO] = 0.5 + 0.058 = 0.56$

b)

| | $H_2$ | + $CO_2$ | ⇌ $H_2O$ | + $CO$ |
|---|---|---|---|---|
| Initial | 0.1 | 0.2 | 0.3 | 0.4 |
| Equilibrium | 0.1-x | 0.2-x | 0.3+x | 0.3+x |

$$K_{eq} = 1.6 = \frac{(0.3+x)(0.4+x)}{(0.1-x)(0.2-x)} = \frac{0.12+0.7x+x^2}{0.02-0.3x+x^2}$$

$$0.12 + 0.7x + x^2 = 0.032 - 0.48x + 1.6x^2$$

$$0 = -0.088 - 1.18x + 0.6x^2$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{1.18 \pm \sqrt{(1.18)^2 - 4(0.6)(-0.088)}}{2(0.6)}$$

$x = 2.039$ or $x = -0.076$

$[H_2] = 0.1717$

$[CO_2] = 0.2717$

$[H_2O] = 0.228$

$[CO] = 0.328$