50) $N_2O_4 \rightarrow 2NO_2$   $K_p = .25$

a. 4.5 atm $N_2O_4$

$$K_p = \frac{(P_{NO_2})^2}{P_{N_2O_4}}$$

| | $N_2O_4$ | $\rightarrow 2NO_2$ |
|---|---|---|
| I | 4.5 | 0 |
| C | $-x$ | $+2x$ |
| E | $4.5-x$ | $2x$ |
| | $4.5-x$ | $2(.5)$ |
| | 4 ATM | 1 ATM |

$$0.25 = \frac{(2x)^2}{4.5-x}$$

$1.125 - 0.25x = 4x^2$

$0 = 4x^2 + 0.25x - 1.125 = 0$

$x = .5$

b. 9 atm $NO_2$

$K_p = 4$

$$K_p = \frac{P_{N_2O_4}}{(P_{NO_2})^2}$$

| | $2NO_2$ | $\rightarrow N_2O_4$ |
|---|---|---|
| I | 9.0 | 0 |
| C | $-2x$ | $+x$ |
| E | $9-2x$ | $x$ |
| | $9-(2\times4)$ | 4 |
| | 1 atm | 4 atm |

$$4 = \frac{x}{(9-2x)^2} \quad (9-2x)(9-2x)$$

$$4 = \frac{x}{81-36x+4x^2}$$

$324 - 145x + 16x^2 = x$
$-x$

$16x^2 - 145x + 324 = 0$

$x =$ ~~5.0625~~ (4)

c. No it does not matter from which direction an equilibrium position is reached.

51) $2NOCl \rightleftharpoons 2NO + Cl_2$  $K = 1.6 \times 10^{-5}$

a. 2 mol NOCl in 2L flask = 1 M  $K = \frac{[NO]^2[Cl]}{[NOCl]^2}$

$2NOCl \rightarrow 2NO + Cl_2$

| | $2NOCl$ | $2NO$ | $Cl_2$ |
|---|---|---|---|
| I | 1 | 0 | 0 |
| C | $-2x$ | $2x$ | $+x$ |
| E | $1-2x$ | $2x$ | $x$ |
| | .9683M | .03175 | .01587M |

$K = \frac{(2x)^2 x}{(1-2x)^2}$

assume x is small ∴ $1-2x = 1$

$1.6 \times 10^{-5} = \frac{4x^3}{4}$

$\frac{1.6 \times 10^{-5}}{4} = x^3$  $x = 0.01587$

b. 1 mol NOCl and 1 mol NO in a 1L flask

$2NOCl \rightarrow 2NO + Cl_2$

| | $2NOCl$ | $2NO$ | $Cl_2$ |
|---|---|---|---|
| I | 1 | 1 | 0 |
| C | $-2x$ | $+2x$ | $+x$ |
| E | $1-2x$ | $1+2x$ | $x$ |
| | 0.999968 M | 1.000032M | $1.6 \times 10^{-5}$ M |

$K = \frac{(1+2x)^2 x}{(1-2x)^2}$

assume x is small ∴ $1-2x = 1$ + $1+2x = 1$

$1.6 \times 10^{-5} = \frac{(1)^2 x}{(1)^2}$

$1.6 \times 10^{-5} = x$

C. 2 mol NOCl and 1 mol $Cl_2$ in a 1L flask

$2NOCl \rightarrow 2NO + Cl_2$  $K = \frac{(2x)^2(1+x)}{(2-2x)^2}$  x is small ∴

| | $2NOCl$ | $2NO$ | $Cl_2$ |
|---|---|---|---|
| I | 2 | 0 | 1 |
| C | $-2x$ | $+2x$ | $+x$ |
| E | $2-2x$ | $2x$ | $1+x$ |
| | 1.992 M | .008 M | 1.004 M |

$1+x = 1$, $2-2x = 2$

$1.6 \times 10^{-5} = \frac{4x^2}{(2)^2}$  $.000016 = x^2$

$x = .004$

52) $N_2O_4 \rightleftharpoons 2NO_2$ $K = 4.0 \times 10^{-7}$

1 mol $N_2O_4$ in a 10 L vessel.
0.1 M

| | $N_2O_4 \rightarrow$ | $2NO_2$ |
|---|---|---|
| I | 0.1 | 0 |
| C | $-x$ | $+2x$ |
| E | $0.1-x$ | $2x$ |
| | 0.0999 M | 0.0002 M |

$K = \frac{[NO_2]^2}{[N_2O_4]}$

$K = \frac{(2x)^2}{(0.1-x)}$

assume x is small ∴ $0.1 - x = 0.1$

$4.0 \times 10^{-7} = \frac{4x^2}{0.1}$

$x = 0.0001$

53) $2CO_2 \rightleftharpoons 2CO + O_2$ $K = 2.0 \times 10^{-6}$

2 mol $CO_2$ in 5 L vessel
0.4 M

| | $2CO_2$ | $2CO$ | $O_2$ |
|---|---|---|---|
| I | 0.4 | 0 | 0 |
| C | $-2x$ | $+2x$ | $+x$ |
| E | $0.4-2x$ | $+2x$ | $+x$ |
| | 0.391 M | 0.00862 M | 0.00431 M |

$K = \frac{[CO]^2[O_2]}{[CO_2]^2}$

$K = \frac{(2x)^2 x}{(0.4-2x)^2}$

x is assumed small ∴ $0.4 - 2x = 0.4$

$2.0 \times 10^{-6} = \frac{(2x)^2 x}{(0.4)^2}$

$2.0 \times 10^{-6} = \frac{4x^3}{.16}$

$x = 0.00431$

54) $COCl_2 \rightleftharpoons CO + Cl_2$ $\quad K_p = 6.8\times10^{-9}$

| | $COCl_2$ | $CO$ | $Cl_2$ |
|---|---|---|---|
| I | 1 atm | 0 | 0 |
| C | $-x$ | $+x$ | $+x$ |
| E | $1-x$ | $x$ | $x$ |
| | 0.99991 atm | $8.246\times10^{-5}$ atm | $8.246\times10^{-5}$ atm |

$$K_p = \frac{P_{CO}P_{Cl_2}}{P_{COCl_2}}$$

$$K = \frac{(x)(x)}{(1-x)}$$

$$6.8\times10^{-9} = \frac{x^2}{1}$$

$x = 0.000082462$ $\quad$ x is small $\therefore$ $1-x = 1$

55) $NH_4OCONH_2(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$ $\quad K_p = 2.9\times10^{-3}$

| | $NH_4OCONH_2(s)$ | $NH_3$ | $CO_2$ |
|---|---|---|---|
| I | | 0 | 0 |
| C | | $+2x$ | $x$ |
| E | | $2x$ | $x$ |

$K_p = (P_{NH_3})^2 P_{CO_2}$

$P_{CO_2} = 0.0898$ atm

$P_{NH_3} = 0.1797$ atm

$P_{total} = 0.2695$ atm

$$K_p = (2x)^2 x$$

$$2.9\times10^{-3} = 4x^3 \qquad x = 0.0898$$

56) $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$ $\quad$ Total Press = 4.4

? $K_p$ =

| | $NH_4Cl(s)$ | $NH_3$ | $HCl$ |
|---|---|---|---|
| I | | 0 | 0 |
| C | | $+x$ | $+x$ |
| E | | $x$ | $x$ |
| | | 2.2 atm | 2.2 atm |

$K_p = (P_{NH_3})(P_{HCl})$

$P_{total} = x + x$ $\quad K_p = (2.2)(2.2)$

$4.4 = 2x$ $\quad K_p = 4.84$

$x = 2.2$

57) $UO_2$ (s) + 4HF (g) ⇌ $UF_4$ (g) + $2H_2O$ (g) @ equilibrium

a. add $UO_2$ (s) = NO shift

b. HF reacting w/ glass container = Shift Left

c. $H_2O$ vapor is removed = Shift Right.

58) Increase volume of container

a. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ Shift Left
b. $PCl_{5(g)} \rightarrow PCl_{3(g)} + PCl_{2(g)}$ Shift Right
c. $H_{2(g)} + F_{2(g)} \rightarrow 2HF_{(g)}$ no shift
d. $COCl_{2(g)} \rightarrow CO_{(g)} + Cl_{2(g)}$ Shift Right
e. $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$ Shift Right

59) $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$ + heat

a. $CO_2(g)$ removed = shift Right
b. $H_2O(g)$ added = shift Right
c. He(g) added to increase Pressure = no shift
d. Temperature is increased = Shift left
e. volume of Container decreased = No Shift

60) Heat↓ $2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_2(g)$  $\Delta H^\circ = 197$ KJ (endothermic

a. $O_2(g)$ added = shift left - moles $SO_3$ increase
b. decrease volume of Container = shift left - moles $SO_3$ increase
c. Ar(g) added to increase pressure = no shift - moles $SO_3$ stays Same
d. Temperature is decreased = Shift left - moles $SO_3$ increase
e. $SO_2(g)$ is removed = shift Right - moles $SO_3$ decrease

61) $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$ + heat

a $H_{2(g)}$ is added = Shift Left

b. $I_{2(g)}$ is removed = Shif Right

c. $HI_{(g)}$ is removed = Shift Left

d Ar (g) is added = no shift

e. Volume of container is doubled = no shift

f. Temperature is decreased = Shift Right

62) Heat + $CH_{4(g)} + H_2O \xrightleftharpoons[750°C]{Ni\ Cat.} CO_{(g)} + 3H_{2(g)}$

a. $H_2O_{(g)}$ is removed = Shift Left

b. Temperature increased = Shift Right

c. inert gas added = No shift

d. $CO_{(g)}$ is removed = Shift Right

e. Container volume tripled = Shift Right.

63) Heat + $(NH_4)_2CO_{3(s)} \rightleftharpoons 2NH_{3(g)} + CO_{2(g)} + H_2O_{(g)}$

increase temperature would increase the ammonia smell because the reaction would shift Right.

64) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

$$K_p = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

as Temp. ↑ Kp ↓ ∴

as Temp ↑ $[NH_3]$ ↓ and $[N_2]$ + $[H_2]$ ↑ ∴

Heat must be a product which makes the reaction exothermic.