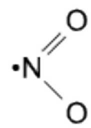
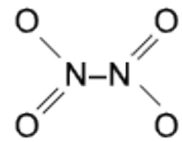
Chapter 9 - Lecture Worksheet 1

1A. LA Smog is composed of nitrogen oxide emissions. Draw Lewis structures:

$2NO_2(g)$ <------> $N_2O_4(g)$





Break no bonds ($E_{in} = 0$) ... Make one bond ($E_{out} > 0$)
EXOTHERMIC reaction

B. This reactions is: **1.** ENDOTHERMIC **2. EXOTHERMIC** **3.** CANNOT TELL

C. At equilibrium:

1. $[NO_2] = [N_2O_4]$
2. $[NO_2]^2 = [N_2O_4]$
3. $2[NO_2] = [N_2O_4]$
4. $k_{forward} = k_{reverse}$
5. **$Rate_{forward} = Rate_{reverse}$**
6. Both 1 & 4 are correct
7. Both 2 & 4 are correct
8. Both 3 & 4 are correct
9. Both 1 & 5 are correct
0. 1, 4 & 5 are all correct

D. Experimental data. Draw some conclusions:

Initial Concs (M)		Final Concs (M)	
$[NO_2(g)]_0$	$[N_2O_4(g)]_0$	$[NO_2(g)]_{eq}$	$[N_2O_4(g)]_{eq}$
0.000	**0.670**	**0.0547**	**0.643**
0.0500	0.445	0.0457	0.448
0.0300	0.500	0.0475	0.491
0.0400	0.600	0.0523	0.594
0.200	**0.00**	**0.0204**	**0.0898**

Ratios of Equilibrium Concentrations (25°C)

$[N_2O_4(g)] / [NO_2(g)]$	$[N_2O_4(g)] / [NO_2(g)]^2$
11.76	**215**
9.80	**215**
10.34	**218**
11.36	**217**
4.4	**216**

Start with different initial concentrations, always get more N_2O_4 than NO_2 at equilibrium. Doesn't matter if start with all NO_2 or all N_2O_4. Independent of direction.
Ratio $[N_2O_4(g)] / [NO_2(g)]^2$ = constant.

E. Why does this work ? Assume a 1 step mechanism and find the ratio **($k_{forward} / k_{reverse}$)**

$Rate_{forward} = Rate_{reverse}$

$$k_{forward}[NO_2]^2 = k_{reverse}[N_2O_4]$$

$$\left(\frac{k_{forward}}{k_{reverse}}\right) = \frac{[N_2O_4]}{[NO_2]^2} = Constant = K_c$$ **... the Equilibrium Constant**

2. Write equilibrium constant expression for:

$N_2(g) + 3H_2(g)$ <------> $2NH_3(g)$

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

For reaction A at 25^0C, **K_{eq} = 3.5 x 10^8**.

We can say that at equilibrium:

1. **There is a lot of NH_3 relative to N_2 and H_2**
2. There is a lot of N_2 relative to NH_3 and H_2
3. There is a lot of H_2 relative to NH_3 and N_2
4. There is about the same amount of NH_3 as N_2 and H_2
5. Cannot tell from the information given.

---

3. Write equilibrium constant expression for:

$CaCO_3(s)$ <------> $Ca^{2+}(aq)$ + $CO_3^{2-}(aq)$

$$K_c = [Ca^{2+}(aq)][CO_3^{2-}(aq)]$$

Note: $[CaCO_3(s)]$ = constant

Do not include pure solids or pure liquids in K expression

For reaction B at 25^0C, **K_{eq} = 9.8 x 10^{-9}**.

We can say that:

1. $CaCO_3(s)$ is very soluble.
2. **$CaCO_3(s)$ is not very soluble.**
3. Cannot tell from the information given.

---

4. Write the equilibrium constant expression for: **$2NH_3(g)$ <------> $N_2(g)$ + $3H_2(g)$**

How is this related to the expression for K in question **2** above ?

$$K_4 = \frac{[N_2][H_2]^3}{[NH_3]^2} = 1/K_2$$

---

5. Write the equilibrium constant expression for: 1/2 **$N_2(g)$ + 3/2 $H_2(g)$ <------> $NH_3(g)$**

How is this related to the expression for K in question **2** above ?

$$K_5 = \frac{[NH_3]}{[N_2]^{1/2}[H_2]^{3/2}} = (K_2)^{1/2}$$

---

6. Conclusions ?

Reverse reaction - Take reciprocal of K

Multiply reaction by n - Raise K to power of n

PRS Answers	
1. $K = K_A$	6. $K = (K_A)^2$
2. $K = (1/K_A)$	7. $K = (1/K_A)^{1/2}$
3. $K = 2\ (1/K_A)$	8. $K = (1/2)(1/K_A)^{1/2}$
4. $K = 2K_A$	9. $K = (K_A)^{1/2}$
5. $K = (1/K_A)^2$	