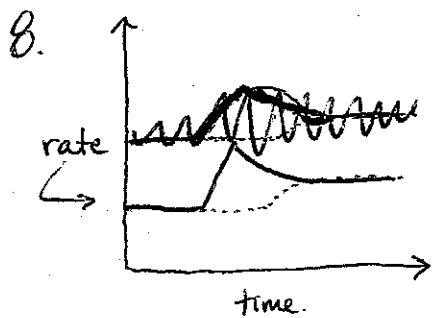


# EQUILIBRIUM REVIEW

## KEY

1. The reverse reaction is occurring at the same rate as the forward rxn, thus replacing the  $\text{CrO}_4^{2-}$  that is reacting.
  - 2a) Because MICROSCOPIC (molecular) changes are occurring even though there are no observable MACROSCOPIC changes.  
Fwd rate = Reverse rate.
  - b) Concentrations of reactants and products remain CONSTANT.
3. See notes. (booklet)
4. Colour is an example of a macroscopic property. Colour is constant at equilibrium because the forward rate equals that of the reverse, thus replacing reactants as fast as they're used.
- 5-a) Enthalpy is decreasing as heat is released (EXOTHERMIC)
- b) Entropy is minimized (less moles of gas on products' side).  
ie. less 'disorder'!
6. Yes. Decreasing enthalpy promotes reverse reaction, but entropy is maximized in the forward rxn.
- 7a)  $\downarrow$  b)  $\uparrow$  c)  $\downarrow$  d) ~~initial~~  $\uparrow$  (no initial  $\uparrow$  because we're talkin' MOLES; subsequent  $\uparrow$  due to equilibrium shift to (R)). e)  $\uparrow \downarrow = \uparrow$  (net) f)  $\downarrow \uparrow = \downarrow$  (net)



— forward  
- - - reverse

Initially, forward rxn<sup>rate</sup> will increase. Reverse rate will remain unchanged until more product is produced. Forward rate then gradually slows while reverse rate speeds up. Overall rates increase at new equilibrium due to more overall molecules.

9. a) 5 seconds:  $K_{eq} = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.800\text{M})^2}{(0.900\text{M})} = \boxed{0.711}$

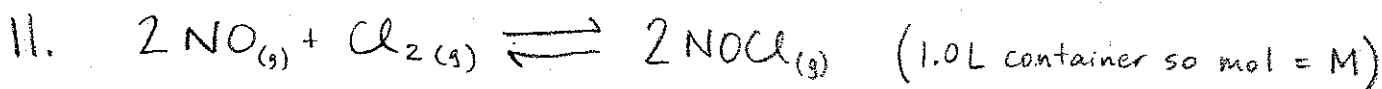
15 seconds:  $K_{eq} = \frac{(0.840\text{M})^2}{(0.880\text{M})} = \boxed{0.802}$       25 seconds:  $\frac{(0.860\text{M})^2}{(0.920\text{M})} = \boxed{0.804}$

b)  $K_{eq}$  increases so [products] increases in relation to [reactants]  
 Change is  $\uparrow$  temperature. (Shift to products)

c)  $K_{eq}$  does NOT change!  $\therefore$  not a temp. change.  
 Change is increasing pressure. Both [ ]s go up initially,  
 then SHIFT to reactants occurs.

10a)  $t_1$ : Added HI b)  $t_2$ : Incr. volume (Decr. pressure) \* no shift!

c)  $t_3$ : Incr. temp. d)  $t_4$ : Removed  $I_2$



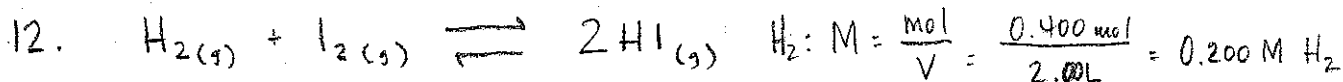
I 0.90 M 0.60 M 0 M

C -0.56 M -0.28 M +0.56 M

E 0.34 M 0.32 M 0.56 M

$$K_{eq} = \frac{[NOCl]^2}{[NO]^2 [Cl_2]} = \frac{(0.56)^2}{(0.34)^2 (0.32)}$$

$K_{eq} = 8.5$



I 0.200 M 0.100 M 0 M

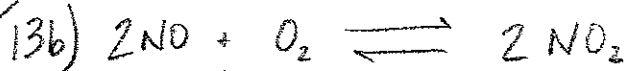
C -0.080 M -0.080 M +0.160 M

E 0.120 M 0.020 M 0.160 M

$I_2: M = \frac{0.200 mol}{2.00L} = 0.100 M I_2$

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = \frac{(0.160 M)^2}{(0.120 M)(0.020 M)}$$

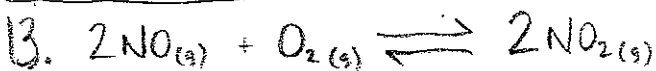
$K_{eq} = 11$



$$6.45 \times 10^5 = \frac{[NO_2]^2}{[NO]^2 (1.0 M)}$$

$803 = \frac{[NO_2]}{[NO]}$

$K_{eq} > 1$  so  $[NO_2] > [NO]$

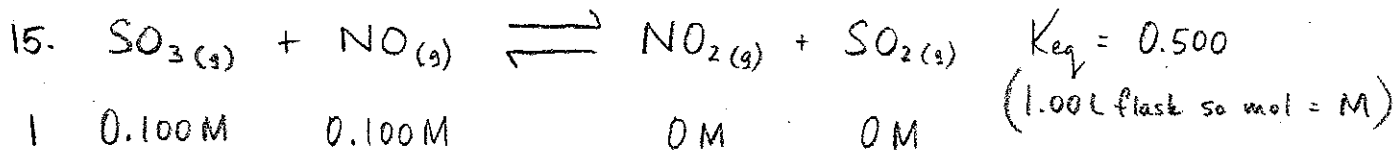
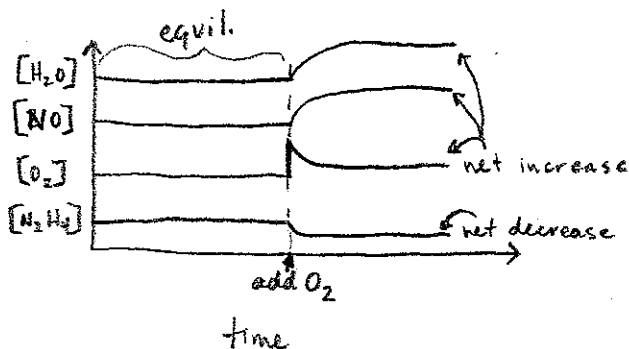


a)  $K_{eq} = \frac{[NO_2]^2}{[NO]^2 [O_2]}$



a)  $O_2$ ,  $NO$ ,  $H_2O$

b)  $N_2H_4$



I 0.100M 0.100M 0M 0M

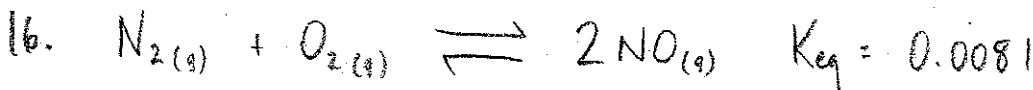
C -x -x +x +x

E (0.100-x)M (0.100-x)M xM xM

let  $x = \text{increase in } [NO_2] = [SO_2]$

$$0.500 = \frac{x^2}{(0.100-x)^2} \quad (\text{SQUARE ROOT BOTH SIDES!})$$

$$0.707107 = \frac{x}{0.100-x} \longrightarrow x = 0.0414 \quad \therefore [SO_2] @ \text{equil.} = 0.0414 M$$



I 0.0400M 0.0400M 0M

C -x -x +2x

E (0.0400-x)M (0.0400-x)M 2xM

$$N_2: M = \frac{\text{mol}}{V} = \frac{0.200 \text{ mol}}{5.00L} = 0.0400M N_2$$

$$= 0.0400M O_2$$

let  $x = \text{decrease in } [N_2] = [O_2]$

$$0.0081 = \frac{(2x)^2}{(0.0400-x)^2} \quad (\text{SQUARE ROOT BOTH SIDES!})$$

$$0.090 = \frac{2x}{0.0400-x} \Rightarrow x = 0.00172$$

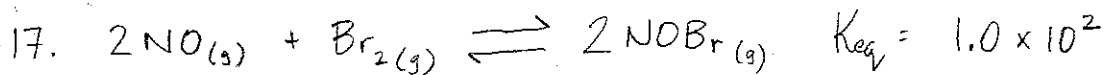
$$[N_2] = [O_2] = 0.0400M - 0.00172M = 0.0383M$$

$\therefore @ \text{equilibrium:}$

$$[NO] = 0.0034M$$

$$[N_2] = 0.0383M$$

$$[O_2] = 0.0383M$$



I 0M 0M xM

\* Remember: 2.0L vessel!

C 0.0800M 0.0400M -0.0800M

Let  $x$  = Conc. of NOBr present to begin reaction.

E 0.0800M 0.0400M  $x - 0.0800M$

$$K_{eq} = \frac{[\text{NOBr}]^2}{[\text{NO}]^2 [\text{Br}_2]} \rightarrow 1.0 \times 10^2 = \frac{(x - 0.0800)^2}{(0.0800)^2 (0.0400)}$$

2 sig figs

$$0.0256 = (x - 0.0800)^2$$

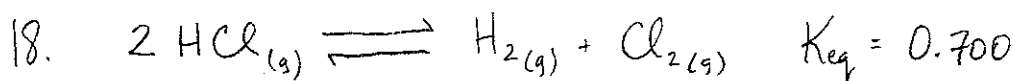
$$0.16 = x - 0.0800$$

$$0.24 = x$$

→ 0.24 M NOBr

$$\text{mol} = MV = (0.24 \text{ M})(2.00 \text{ L})$$

$$= 0.48 \text{ mols NOBr}$$



I 0M x x

Let  $x = [\text{H}_2] = [\text{Cl}_2]$  placed into container.

C 0.240M -0.120M -0.120M

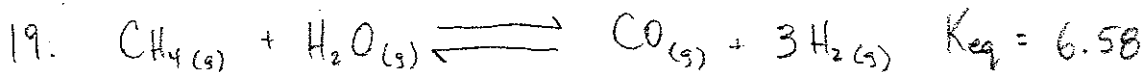
E 0.240M  $(x - 0.120)M$   $(x - 0.120)M$

$$K_{eq} = \frac{[\text{H}_2][\text{Cl}_2]}{[\text{HCl}]^2} \Rightarrow 0.700 = \frac{(x - 0.120)^2}{(0.240)^2}$$

$$0.04032 = (x - 0.120)^2$$

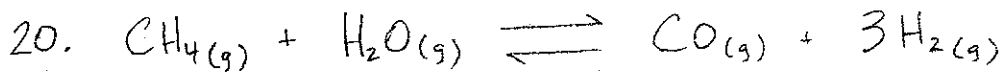
$$0.200798 = x - 0.120$$

$$x = 0.321 \text{ M} = [\text{H}_2] = [\text{Cl}_2]$$



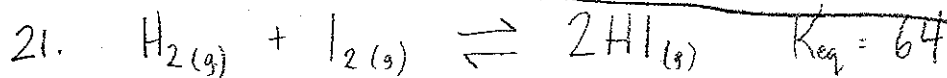
Find Trial  $K_{eq} = \frac{[\text{CO}][\text{H}_2]^3}{[\text{CH}_4][\text{H}_2\text{O}]} = \frac{[0.320 \text{ M}][0.380]^3}{[0.360 \text{ M}][0.0800 \text{ M}]} = 5.27$

Trial  $K_{eq} < K_{eq}$  Equilibrium shifts to right (products)  
[CH<sub>4</sub>] DECREASES



As temp. increases,  $K_{eq}$  increases.  $\therefore$  fwd reaction is ENDOTHERMIC

temp  $\uparrow$   $\rightarrow$   $K_{eq} \uparrow \rightarrow \frac{[P]}{[R]} \uparrow \rightarrow$  shift (R)  $\rightarrow$  fwd. faster  $\rightarrow$  endo fwd  
 temp  $\uparrow \rightarrow$  both rates  $\uparrow \rightarrow$  endo  $\uparrow$  more  $\rightarrow$  endo fwd



Calculate Trial  $K_{eq}$  ( $Q$ ). Let  $x$  = conc. of all 3 species

$$K_{eq} = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{x^2}{(x)(x)} = \frac{x^2}{x^2} = 1$$

$$1 < 64 \Rightarrow \text{Trial } K_{eq} < K_{eq}$$

Equilibrium shifts to PRODUCTS (RIGHT)