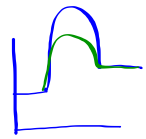
Review worksheets #2.doc

Review Section 18.1-18.5

1. Given the reaction: 3A + 2B → C + 2D is exothermic.

Predict the shift in equilibrium when the following changes are imposed

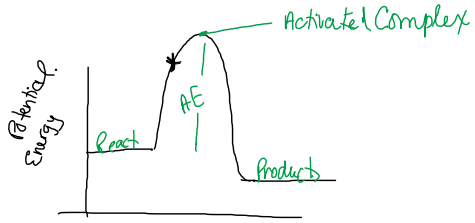
a. Addition of A RIGHT
b. Decrease the amount of B Left
c. Increase pressure RIGHT
d. Inc temperature Left
e. Add a catalyst No change in equilibrium
f. Write the equilibrium law for the reaction

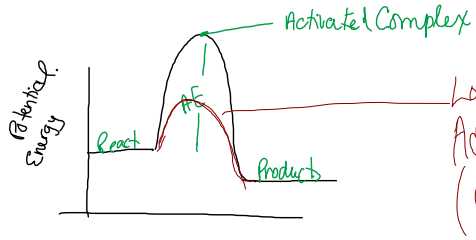


a catalyst lowers activation energy

$3A + 2B \overset{HEAT}{\rightleftharpoons} C + 2D + energy$

$K_{eq} = \frac{[C][D]^2}{[A]^3[B]^2}$



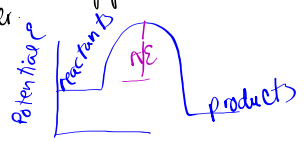


Lower the Activation Energy (addition of a catalyst)

$A + B \rightleftharpoons C + D$

$\text{energy} + X + Y \overset{40\%}{\underset{30\%}{\rightleftharpoons}} W + Z \qquad K_{eq} < 1$

Catalyst will not affect equilibrium: However, a catalyst will increase the rate of the reaction. It increases the rate of the reaction by lowering the activation energy so the reaction happens faster.



same reaction with addition of a catalyst

* Know: Le Chatelier's Principle, Activation Energy, Activated Complex, Catalyst } Definitions

2. Given the reaction: : $CH_{4\,(g)} + H_2O_{(g)} \rightarrow CO_{(s)} + 3H_{2\,(g)}$ is exothermic. Predict the shift in equilibrium when the following changes are imposed

a. Addition of water vapor Right

b. Decrease the amount of $H_{2(g)}$ Right

c. Decrease pressure Right

d. Dec temperature Right

e. Add a catalyst No change in equilibrium

f. Write the equilibrium law for the reaction.

g. Given the following concentrations are founf in a 1L solution : $[CH_4]$ = 0.12 mol $[H_{2(g)}]$ = 0.09mol ; $[CO]$ = 0.25mol ; $[H_2O]$ = 0.14mol

Determine the value of Keq. Does the reaction favor the products or reactants(how do you know)?

(f)

$$CH_{4(g)} + H_2O_{(g)} \rightleftarrows CO_{(s)} + 3H_{2(g)} + \text{energy}$$

$$K_{eq} = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$

(g)

$$K_{eq} = \frac{[0.25][0.09]^3}{[0.12][0.14]}$$

$K_{eq} = 0.0108$

∴ favor reactants

NOTE: An inc in volume can be looked at as a decrease in pressure.

P ↑ V ↓ } inversely proportional

P ↓ V ↑ }

Extra:

$$Fe^{+3}(aq) + SCN^{-1}(aq) \rightleftharpoons FeSCN^{+2}(aq)$$

yellow **dark red**

$K_{eq} = 0.026$ ∴ favors reactants: more yellow

add Fe^{3+} turn toward dark red

The reaction is endothermic, what will happen if we heat it? ***It will shift right and get darker red***

$$Fe^{+3}(aq) + SCN^{-1}(aq) \rightleftharpoons FeSCN^{+2}(aq)$$

yellow **dark red**

$Co(H_2O)_6^{2+} + 4\ Cl^- \leftrightarrow CoCl_4^{2-} + 6\ H_2O$

pink blue

Keq = 0.028 a stress is applied and the new Keq is 0.91. What side does the equilibrium shift to?

3. Given the reaction: : $Pb_3(PO_4)_{2\,(s)} \rightleftharpoons 3Pb^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)}$.

Predict the shift in equilibrium when the following changes are imposed

a. Addition of $Al_2(SO_4)_3$ → No reaction

b. Decrease the amount of PO_4^{3+} Right

c. What does the addition of a catalyst do to the activation energy? lowers it

d. Addition of $AlPO_{4\,(s)}$ (same as adding PO_4^{3-} common ion) - left

e. Addition of SnCl → No change

f. Write the equilibrium law for the reaction.

g. Write the solubility product expression, how does it differ from Keq

(f) $K_{eq} = \dfrac{[Pb^{2+}]^3[PO_4^{3-}]^2}{[Pb_3(PO_4)_2]}$

(g) $K_{sp} = [Pb^{2+}]^3[PO_4^{3-}]^2$ only products are listed

$Pb_3(PO_4)_{2\,(s)} \rightleftharpoons 3Pb^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)}$

d. Addition of $AlPO_{4\,(s)}$ (left)

e. Addition of SnCl no change

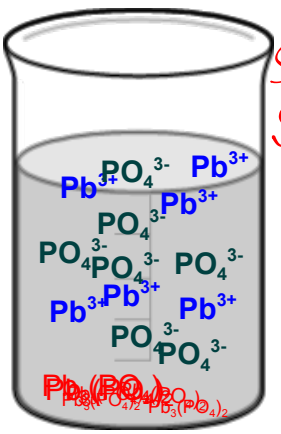
$Pb_3(PO_4)_2$

Pb^{3+}

PO_4^{3-}

Al 3+ PO4

SnCl Sn 1+ Cl



4. Which substance is more soluble in water at 25°C:

a. Copper(II) sulfide or lead(II) sulfide? Why?

Ksp = 8.0×10^{-37} Ksp = 3.0×10^{-28}

$CuS \rightleftharpoons Cu^{2+} + S^{2-}$

Both favor reactants ($K_{sp} < 1$)
however, lead(II) sulfide is larger ∴ more soluble

Which is more soluble.

$AB \rightleftharpoons A^+ + B^-$

$K_{sp} = 793$

$CD \rightleftharpoons C^+ + D^-$

$K_{sp} = 804$

larger K_{sp} = more soluble

5. What is the concentration of iron(II) ions and hydroxide ions in a saturated solution of $Fe(OH)_2$ at 25°C. ($K_{sp} = 7.9 \times 10^{-16}$)

$$Fe(OH)_2 \rightleftharpoons \underset{x}{Fe^{2+}} + \underset{2x}{2OH^-}$$

$$K_{sp} = [Fe^{2+}][OH^-]^2$$

$$7.9\times10^{-16} = (x)(2x)^2$$

$$7.9\times10^{-16} = x \cdot 4x^2$$

$$7.9\times10^{-16} = 4x^3$$

$$\frac{7.9\times10^{-16}}{4} = x^3$$

$$1.975\times10^{-16} = x^3$$

$$(1.975\times10^{-16})^{\frac{1}{3}} = x$$

$$5.82\times10^{-6} = x$$

$[Fe^{2+}] = x = 5.82\times10^{-6}$ mol/L

$[OH^-] = 2x = 1.164\times10^{-5}$ mol/L

6. What is the concentration of zinc ions and phosphate ions in a saturated solution of $Zn_3(PO_4)_2$ at at 25°C. ($Ksp = 9.0 \times 10^{-33}$)

$Zn_3(PO_4)_2 \rightleftharpoons 3Zn^{2+} + 2PO_4^{3-}$

$3x \quad 2x$

$K_{sp} = [Zn^{2+}]^3[PO_4^{3-}]^2$

$9.0\times10^{-33} = (3x)^3(2x)^2$

$9.0\times10^{-33} = 27x^3 \cdot 4x^2$

$9.0\times10^{-33} = 108x^5$

$\frac{9.0\times10^{-33}}{108} = x^5$

$8.33\times10^{-35} = x^5$

$(8.33\times10^{-35})^{1/5} = x$

$1.528\times10^{-7} = x$

$[Zn^{2+}] = 3x$

$= 3(1.528\times10^{-7})$

$= 4.584\times10^{-7}\ M$

$[PO_4^{3-}] = 2x$

$= 2(1.528\times10^{-7})$

$= 3.056\times10^{-7}\ mol/L$

What is the concentration of phosphate ions in a satutated solution of Cobalt(II) phosphate. [Ksp of Cobalt(II) phosphate is 2.05×10^{-35}]

$Co_3(PO_4)_2 \rightleftharpoons 3Co^{2+} + 2PO_4^{3-}$

$3x \qquad 2x$

$K_{sp} = [Co^{2+}]^3[PO_4^{3-}]^2$

$2.05\times10^{-35} = (3x)^3(2x)^2$

$2.05\times10^{-35} = 27x^3 \cdot 4x^2$

$2.05\times10^{-35} = 108x^5$

$\frac{2.05\times10^{-35}}{108} = x^5$

$1.8981\times10^{-37} = x^5$

$(1.8981\times10^{-37})^{1/5} = x \Rightarrow (1.8981\times10^{-37})\wedge(1/5)$

$4.52\times10^{-8} = x$

$x = 4.52\times10^{-8}$

$[Co^{2+}] = 3x$

$= 3(4.52\times10^{-8})$

$= 1.356\times10^{-7}\,M$

$[PO_4^{3-}] = 2x$

$= 2(4.52\times10^{-8})$

$= 9.04\times10^{-8}\,M$

OMIT

7. What is the equilibrium concentration of copper (II) ions in a 1.0L solution of copper(II) carbonate to which 0.033 mol of calcium carbonate is added . Ksp $CuCO_3$ = 1.4×10^{-10}

(Common Ion)

$CuCO_3 \rightleftharpoons Cu^{2+} + CO_3^{2-}$

x $\quad$ $x + 0.033$

add 0.033 mol $CaCO_3$ $\rightarrow CO_3^{2-}$

$K_{sp} = [Cu^{2+}][CO_3^{2-}]$

$1.4 \times 10^{-10} = (x)(0.033)$

$1.4 \times 10^{-10} = 0.033x$

$\frac{1.4 \times 10^{-10}}{0.033} = x$

$4.24 \times 10^{-9} = x$

$[Cu^{2+}] = x$

$= 4.24 \times 10^{-9}$ mol/L

OMIT

8. What is the equilibrium concentration of silver ions in a 1.0L solution of silver bromide to which 0.00022 mol of thallium(I) bromide, TlBr, has been added .

Ksp AgBr = 5.0×10^{-13}

* Common Ion Br^-

0.00022 mol Br^-

$AgBr \rightleftharpoons Ag^+ + Br^-$

x $x + 0.00022 mol$

$K_{sp} = [Ag^+][Br^-]$

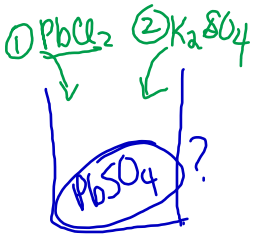
$5.0 \times 10^{-13} = (x)(0.00022)$

$2.27 \times 10^{-9} = x$

$[Ag^+] = x$

$= 2.27 \times 10^{-9} M$

9. Will a precipitate of lead(II) sulfateform if 150ml of 0.006 M lead(II) chloride , $PbCl_2$ is mixed with 200ml of 0.004M potassium sulfate , K_2SO_4 ? (Ksp $PbSO_4$ = 6.3×10^{-7})



Ksp > product of two ions in mixture there is no precipitate

Ksp < product of two ions in mixture there is a precipitate

① $PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$

$0.150\,L \times 0.006\,\frac{mol}{L} = 9 \times 10^{-4}\,\frac{mol}{L}$

$9 \times 10^{-4}\,mol$ $\quad 18 \times 10^{-4}\,mol$

② $K_2SO_4 \rightleftharpoons 2K^+ + SO_4^{2-}$

$0.200\,L \times 0.004\,\frac{mol}{L} = 0.0008\,mol$ $\quad 0.0016\,mol$ $\quad 0.0008\,mol$

$PbSO_4 \rightleftharpoons Pb^{2+} + SO_4^{2-}$

$9 \times 10^{-4}\,M$ $\quad 0.0008\,mol$

150 mL
200 mL
350 mL

K_{sp} $\quad [Pb^{2+}][SO_4^{2-}]$

6.3×10^{-7} ◯ $\left(\frac{0.0009\,mol}{0.35\,L}\right)\left(\frac{0.0008\,mol}{35\,L}\right)$

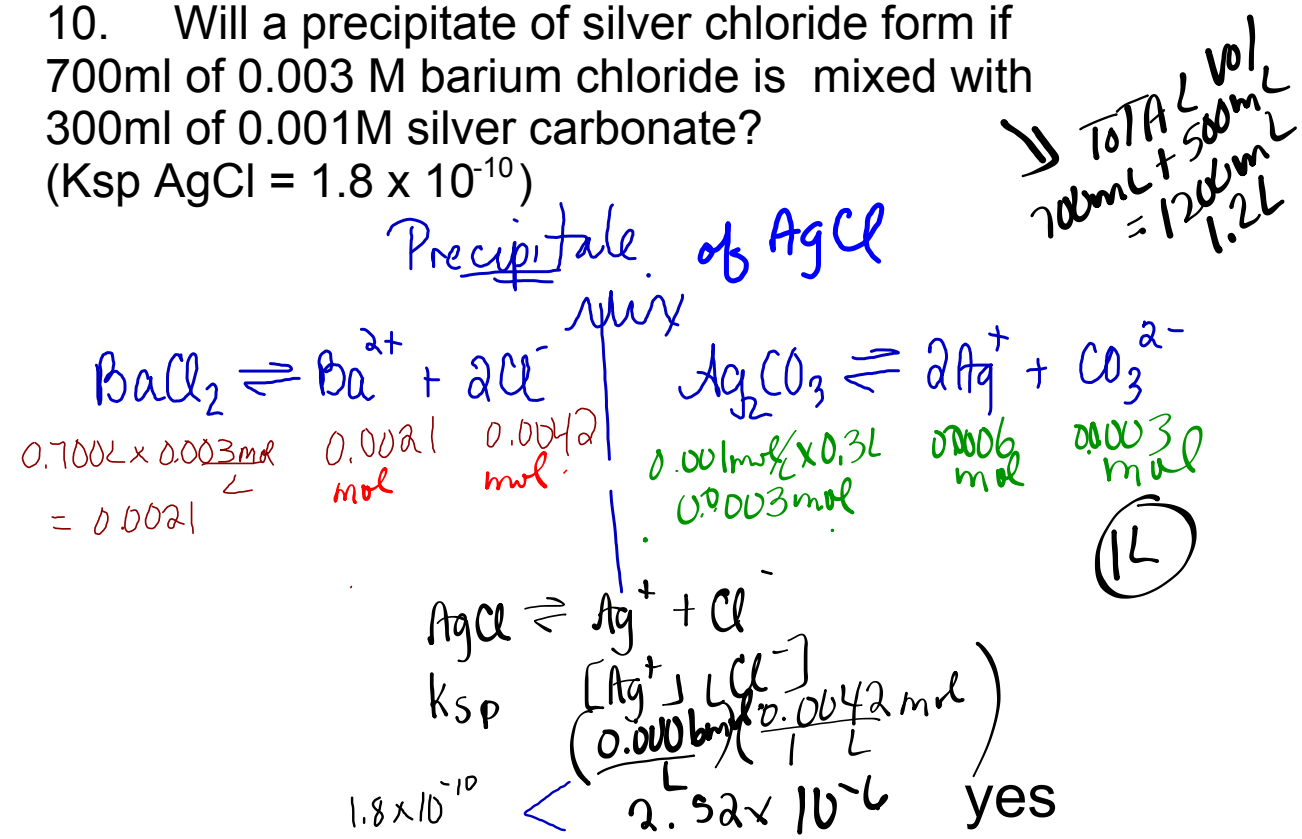
$6.3 \times 10^{-7} < 5.878 \times 10^{-6}$

∴ yes, precipitate will form

Ksp > product of two ions in mixture there is no precipitate

Ksp < product of two ions in mixture there is a precipitate

10. Will a precipitate of silver chloride form if 700ml of 0.003 M barium chloride is mixed with 300ml of 0.001M silver carbonate? (Ksp AgCl = 1.8×10^{-10})



TOTAL VOL 700mL + 500mL = 1200mL = 1.2L

Ksp > product of two ions in mixture there is no precipitate

Ksp < product of two ions in mixture there is a precipitate

EXTRA: Will a precipitate of Barium Fluoride form if 125ml of 0.08 M barium phosphate is mixed with 495 ml of 0.06 M aluminum fluoride? (Ksp BaF_2 = 1.84 x 10^{-7})

TOTAL Volume 125ml + 495 mL = 620 mL (0.62 L)

$Ba_3(PO_4)_2 \rightleftharpoons 3Ba^{2+} + 2PO_4^{3-}$

$0.08\frac{mol}{L} \times 0.125L = 0.01 mol$

$0.01 mol$ | $0.03 mol$ | $0.02 mol$

$AlF_3 \rightleftharpoons Al^{3+} + 3F^-$

$0.06\frac{mol}{L} \times 0.495L = 0.0297 mol$

$0.0297 mol$ | $0.0891 mol$

$BaF_2 \rightleftharpoons Ba^{2+} + 2F^-$

$Ksp = [Ba^{2+}][F^-]^2$

$1.84 \times 10^{-7} \quad \left(\frac{0.03 mol}{0.62}\right)\left(\frac{0.0891 mol}{0.62L}\right)^2$

$1.84 \times 10^{-7} < 9.99 \times 10^{-4}$

yes

Ksp > product of two ions in mixture there is no precipitate

Ksp < product of two ions in mixture there is a precipitate

11. Given the reaction: $Br_{(l)} \rightarrow Br_{(s)}$ more orderly
will the entropy increase or decrease in this reaction?

↓
degree of disorder

l is more disorderly than solid

entropy decreases (disorder)

$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

entropy inc

12. Classify the following as **Spontaneous, Nonspontaneous, Cannot Determine**

a. entropy increases and enthalpy decreases Sponl
b. enthopy decreases and enthalpy increases NS
c. entropy increases and enthalpy increases

If Entropy ↑ ⇒ favours Spontaneous
if Entropy ↓ ⇒ favors nonspont

Enthalpy ↓ favors spont.
Enthalpy ↑ favors NonSpont

(a) Entropy ↑, Enthalpy ↓ ∴ Spont
Sp Sp

(b) Entropy ↓, Enthalpy ↑ ∴ NonSpont
NS NS

(c) Entropy ↑ Enthalpy ↑ ∴ cannot tell
Sp NS

13. Given the following reactions , state the rate law:

a. $2A + 3B \rightarrow 4C + D$

b. $2H_2O_2 \rightarrow 2H_2O + O_2$

(a) rate $= k[A]^2[B]^3$ (b) rate $= k[H_2O_2]^2$

2nd order [A]

third order [B]

5th order overall

14. A combination reaction gave the following data: A + B -> C

Trial #	[A]	[B]	Rate mol/L s
1	0.22	0.50	0.03
2	0.22	2	1.92
3	0.44	0.50	0.06

Determine the order for each reactant and the overall order for the reaction

Write the rate law.

rate = k [A]^1[B]^3

4th order overall

find K

TRIAL 3 $0.06 = K[0.44]^1[0.5]^3$

$K = 1.09$

TRIAL 2 $1.92 = K(0.22)^1(2)^3$

* entropy

[A] = 1st order

[B] = 3rd order } 4th

rate = k [A]^1[B]^3

TRIAL	A	B	rate
1	6	6	2
2	30	6	250
3	6	42	2

$\times 125 \quad (5^{3})$

constant

$\text{rate} = k[A]^{3}[B]^{0}$

step constant it is 0

$H_2SO_4 + H_2O \rightleftharpoons HSO_4^- + H_3O^+$

red clear

heat it it turns clear

Endothermic

15. A combination reaction gave the following data: ___ M + ___ P + ___ W ->

Trial #	[M]	[P]	[W]	Rate mol/L s
1	0.014	0.020	0.030	0.0025
2	0.014	0.020	0.090	0.2025
3	0.14	0.020	0.090	20.25
4.	0.14	0.01	0.090	1.265625

Determine the order for each reactant and the overall order for the reaction. Write the rate law.

$$\text{rate} = k[W]^4[M]^2[P]^4$$

15. A combination reaction gave the following data: ___ M + ___ P + ___ W ->

Trial #	[M]	[P]	[W]	Rate mol/L s
1	0.014	0.020	0.030	0.0025
2	0.014	0.020	0.090	0.2025
3	0.14	0.020	0.090	20.25
4.	0.14	0.01	0.090	1.265625

Determine the order for each reactant and the overall order for the reaction. Write the rate law.

15. A combination reaction gave the following data: ___ M + ___ P + ___ W ->

Trial #	[M]	[P]	[W]	Rate mol/L s
1	0.05	0.03	0.11	1.5
2	0.05	0.12	0.11	1536
3	0.10	0.12	0.11	49152
4.	0.05	0.12	0.99	1536

termine the order for each reactant and the overall order for the reaction. Write the rate law.

rate = $k[P]^5[M]^5[W]^0$

Entropy, Activated Complex, Activation Energy, Le Chatelier's Principle, Equilibrium, Free Energy.

TRIAL	A	B	C	rate
1	0.01	0.01	0.01	5
2	0.01	0.08	0.01	320
3	0.01	0.01	0.05	3125
4	0.09	0.01	0.01	45

8^2 B = 2

64

$\text{rate} = k[A][B]^2[C]^4$

TRIAL	A	B	C	rate
1	0.01	0.01	0.01	5
2	0.01	0.08	0.01	320
3	0.01	0.01	0.05	3125
4	0.09	0.01	0.01	45

$\times 5$

$625 = 5^4$

C = 4

TRIAL	A	B	C	rate
1	0.01	0.01	0.01	5
2	0.01	0.08	0.01	320
3	0.01	0.01	0.05	3125
4	0.09	0.01	0.01	45

$\times 9$

9^1

[A] = 1

$\text{rate} = k[A][B]^2[C]^4$

Review Le Chatelier's Principle:

* Concentration and Energy (Temperature)

Inc Amount => shifts opposite

Dec Amount => shift to where decrease

* Pressure

Inc Pressure shifts to side with least number of moles

Dec. Pressure shifts to side with most number of moles

ENDOTHERMIC = Energy on left

Exothermic = Energy on right

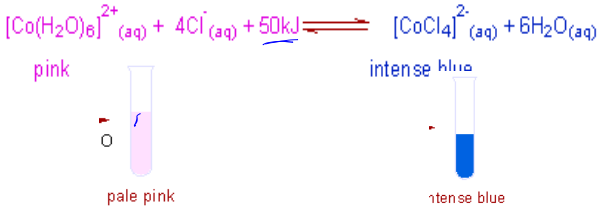
equilibrium:

Reactants $\rightleftharpoons$ Products

forward & reverse reactions occur at the same time:

energy + HCO_3^- + H_2O $\rightleftharpoons$ H_2CO_3 + OH^-

pink clear



energy + $2SO_{2(g)}$ + $O_{2(g)}$ $\rightleftharpoons$ $2SO_{3(g)}$

$K_{eq} = 0.002$; $T = 25^\circ C$

$K_{eq} = 0.28$; $T = 90^\circ C$

K_{eq} ↑ shifted favor products

energy + CH_4 + $3O_2$ $\rightleftharpoons$ CO_2 + $4H_2O$

$K_{eq} = 1.8$ $T = 18^\circ C$

$K_{eq} = 0.6$ $T = 2^\circ C$

favor left when energy taken away

$A + 2B \rightleftharpoons 2C + M$ + energy

$K_{eq} = 50$ $T = 30^\circ C$

$K_{eq} = 120$ $T = 10^\circ C$

Attachments

Review worksheets #2.docx

Review worksheets #2.doc

Review worksheets #3.doc