Fossum
Chem 1B

Answers – Practice Equilibrium Problems

1.

	3 A	+	2 B	⇌	C	+	2 D
start	~~0.80~~ 1.0 M		0.80 M		0		0
Δ	−3x		−2x		+x		+2x
eq.	1.0 − 3x		0.80 − 2x		x		2x

$K_c = 3.7 \times 10^{-10}$

goes → K very small goes a little forward. Ok to neglect x.

$$K_c = \frac{[C][D]^2}{[A]^3[B]^2} = \frac{(x)(2x)^2}{(1.0-3x)^3(0.80-2x)^2}$$ neglect x's

$$K_c = \frac{(x)(4x^2)}{(1.0)^3(0.80)^2} = 3.7 \times 10^{-10}$$

$$4x^3 = 3.7 \times 10^{-10}(1.0)^3(0.80)^2$$

$$x = \sqrt[3]{\frac{(3.7 \times 10^{-10})(1.0)^3(0.80)^2}{4}} = 3.\overline{897} \times 10^{-4}\ M$$

$[A] = 1.0\ M$ $\quad [C] = 3.9 \times 10^{-4}\ M$

$[B] = 0.80\ M$ $\quad [D] = 2x = 7.8 \times 10^{-4}\ M$

2.

	3 A	+	B	⇌	3 C	+	2 D
Start	∅		0.50 M		2.0 M		5.0 M
Δ	~~Start~~ +3x		+x		−3x		−2x
end complete rxn	3x		0.50 + x		2.0 − 3x		5.0 − 2x

$K_c = 3.2 \times 10^{-13}$

must go ← to make some A. K reverse is huge. Goes ← to completion then forward a little to equilibrium. 2 charts.

which is LR?

Need $\frac{3C}{2D} = \frac{1.5C}{1D}$ Have $\frac{\cancel{5.0}D}{\cancel{2.0}}$ $\frac{2.0C}{5.0D}$

Have $\frac{0.4C}{1D}$ not enough C so C is LR.

LR → ∅

C: $2.0 - 3x = \emptyset$

$\frac{2.0}{3} = \frac{3x}{3}$ $\quad x = \frac{2}{3} = 0.\bar{6}667$

$[A] = 3x = 3(0.\bar{6}667) = 2.0$ M

$[B] = 0.50 + 0.\bar{6}667 = 1.1\bar{6}67$ M

$[C] = \emptyset$

$[D] = 5.0 - 2(x) = 3.\bar{6}667$ M

2nd Chart goes forward a little — y is very small!

	3 A	+	B	$\rightleftharpoons$	3C	+	2D
Start	2.0 M		$1.\bar{1}667$ M		$\emptyset$		$3.\bar{6}67$ M
Δ	$-3y$		$-y$		$+3y$		$+2y$
eq.	$2.0-3y$		$1.1\bar{6}67-y$		$3y$		$3.\bar{6}67+2y$

$$K_c = 3.2\times10^{-13} = \frac{[C]^3[D]^2}{[A]^3[B]} = \frac{(3y)^3(3.\bar{6}67+2y)^2}{(2.0-3y)^3(1.1\bar{6}67-y)} = 3.2\times10^{-13}$$

neglect y's

$$\frac{27y^3(3.\bar{6}67)^2}{(2.0)^3(1.1\bar{6}67)} = 3.2\times10^{-13}$$ solve for y

$$y = \sqrt[3]{\frac{(3.2\times10^{-13})(2.0)^3(1.1\bar{6}67)}{(27)(3.\bar{6}67)^2}} = 2.0\times10^{-5}\text{ M}$$

2.0187×10^{-5}

equilibrium concentrations

$[A] = 2.0$ M

$[B] = 1.17$ M

$[C] = 3y = 6.1\times10^{-5}$ M (using unrounded value for y)

$[D] = 3.7$ M

3.

	$3A$	+	$2B$	$\rightleftharpoons$	C	+	$2D$
start	0.80 atm		0.60 atm		0.20 atm		Ø
Δ	$-3x$		$-2x$		$+x$		$+2x$
end	$0.80-3x$		$0.60-2x$		$0.20+x$		$2x$

$K_p = 5.8 \times 10^{10}$

K is huge. Rxn goes forward to make some D. will go to completion → then back a little to get to equilibrium. ←

Need $\frac{3A}{2B} = \frac{1.5A}{1B}$ Have $\frac{0.8A}{0.6B} = \frac{1.3A}{1B}$

not enough A, so A is LR and it goes to zero.

2 charts

$0.80 - 3x = Ø$

$\frac{0.80}{3} = \frac{3x}{3}$

$x = 0.2\bar{6}67$ atm

P_B $0.60 - 2x = 0.60 - 2(0.2667) = 0.0\bar{6}67$ atm (2 dec places)

$P_C = 0.20 + x = 0.20 + 0.2\bar{6}67 = 0.4\bar{6}67$ atm

$P_D = 2x = 2(0.2\bar{6}67) = 0.5\bar{3}33$

K reverse is tiny. Rxn goes ← a little

	$3A$	+	$2B$	$\rightleftharpoons$	C	+	$2D$
i	Ø		0.0667 atm		0.4667 atm		0.5333 atm
Δ	$+3y$		$+2y$		$-y$		$-2y$
eq.	$3y$		$0.0667+2y$ atm		$0.4667-y$		$0.5333-2y$ atm

$$K_p = 5.8\times10^{10} = \frac{P_C P_D^2}{P_A^3 P_B^2} = \frac{(0.4\bar{6}67-y)(0.5\bar{3}33-2y)^2}{(3y)^3(0.0\bar{6}67+2y)^2} = 5.8\times10^{10}$$

neglect y's because they will be very tiny.

$$K_p = \frac{(0.4\bar{6}67)(0.5\bar{3}33)^2}{27y^3(0.0\bar{6}67)^2} = 5.8\times10^{10}$$

$$y = \sqrt[3]{\frac{(0.4\bar{6}67)(0.5\bar{3}33)^2}{27(0.0\bar{6}67)^2(5.8\times10^{10})}} = \sqrt[3]{1.905\times10^{-11}} = \bar{2}.67\times10^{-4}\ M$$

$P_A = 3y = 8.0 \times 10^{-4}$ atm

$P_B = 0.0667 + 2y =$ 0.07 atm

$P_C = 0.4667 - y =$ 0.47 atm

$P_D = 0.5333 - 2y =$ 0.53 atm

4.

	$3A$	+	$2B$	$\rightleftharpoons$	C	+	$2D$	$K_p = 5.8 \times 10^{10}$
Start	0		0		0.20 atm		0.35 atm	Rxn must go reverse to create some A and B.
Δ	$+3x$		$+2x$		$-x$		$-2x$	
eq.	$3x$		$2x$		$0.20-x$		$0.35-2x$	K reverse is very small, so it will go a little bit, in the reverse direction.

$$K_p = 5.8 \times 10^{10} = \frac{P_C P_D^2}{P_A^3 P_B^2} = \frac{(0.20-x)(0.35-2x)^2}{(3x)^3(2x)^2}$$

neglect x's - they will be very small.

$$K_p = \frac{(0.20)(0.35)^2}{27x^3 4x^2} = 5.8 \times 10^{10}$$

$$\frac{(0.20)(0.35)^2}{27 \cdot 4 (5.8 \times 10^{10})} = x^5 \qquad x = \sqrt[5]{\frac{0.20\,(0.35)^2}{(27)(4)(5.8 \times 10^{10})}}$$

$$x = \sqrt[5]{3.911 \times 10^{-15}} = 0.001314$$

$P_A = 3x = 0.0039$ atm

$P_B = 2x = 0.0026$ atm

$P_C = 0.20 - x = 0.20$ atm

$P_C = 0.35 - 2x = 0.35$ atm