

# Material Shift

Performed BEFORE the I.C.E. Equilibrium Solution

...when a strong/large equilibrium shift is predicted.

Converting Products to Reactants

Converting Reactants to Products

Making equilibrium mathematics  
more easily solved

Problem 1:  $K_c \ll 1$  Favors Reactants and only Reactants initially present  
 $X \sim 0$  Assumption valid...No material shift required

Problem 2:  $K_c \ll 1$  Favors Reactants and only Products initially present  
 $X \sim 0$  Assumption Invalid & Material shift required

Problem 3:  $K_c \ll 1$  Favors Reactants and only Products initially present  
 $X \sim 0$  Assumption Invalid & Material shift required

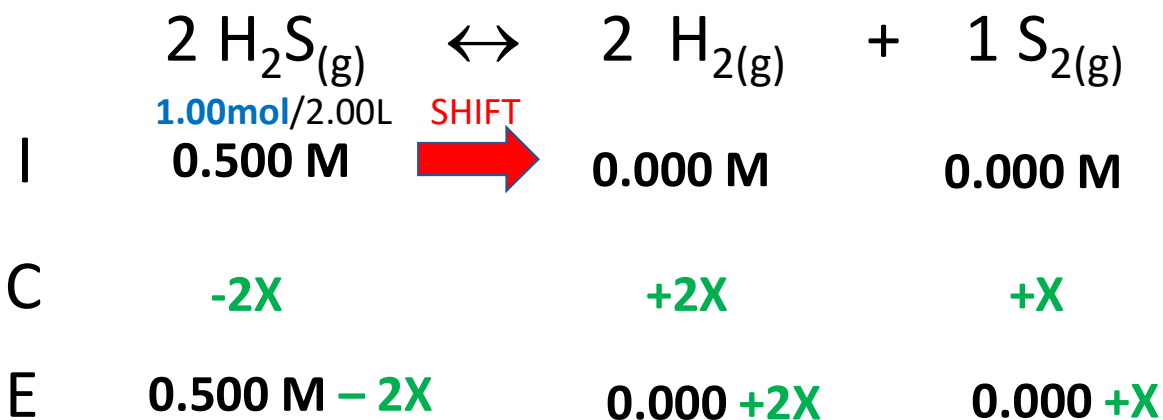
Problem 4:  $K_c \gg 1$  Favors Products  
and BOTH Products and Reactants are initially present.  
 $X \sim 0$  Assumption Invalid & Material shift required



# 1. No Material Shift Required

1.00 mole of  $\text{H}_2\text{S}$  gas is placed in a closed 2.00 liter container  
 Assume that no product is originally present and  
 determine the concentrations of all species after equilibrium is reached.

Reactants!



$$K_c = 1.67 \times 10^{-7}$$

Small  $K_c \Rightarrow$  Favors Reactants

Initially, only reactants are present.

Shifts *weakly* to the right (products).

CAN use  $X \sim 0$  assumption. ☺

Easy math ahead.

Material Shift NOT REQUIRED

$$\frac{[\text{H}_2]^2 [\text{S}_2]}{[\text{H}_2\text{S}]^2} = \frac{(2X)^2 X}{(0.500 - 2X)^2} = \frac{4X^3}{(0.500)^2} \stackrel{\text{Solve for "X"}}{=} 1.67 \times 10^{-7} \quad X = 2.18_{54} \times 10^{-3}$$

X = 0



# 1. No Material Shift Required



$$\text{E} \quad 0.500\text{M} - 2X \quad \quad 2X \quad \quad X$$

$$K_C = 1.67 \times 10^{-7}$$

$$X = 2.18_{54} \times 10^{-3}$$

## i. Equilibrium Concentrations

$$[\text{H}_2\text{S}]_{\text{eq}} = 0.500 - 2X = 0.495_{63} \text{ M} = 0.496 \text{ M}$$

$$[\text{H}_2]_{\text{eq}} = 2X = 4.37_{08} \times 10^{-3} \text{ M}$$

$$[\text{S}_2]_{\text{eq}} = X = 2.18_{54} \times 10^{-3} \text{ M}$$

...most of original reactant remains.

...only small amounts of product form.

## ii. 5% check

$$(0.500 - 2X)^2$$

$$\frac{2X}{0.500} \times 100 = 0.87\%$$

$$0.87\% < 5\% \quad \text{😊}$$

## iii. Equilibrium Check

$$\frac{[\text{H}_2]^2 [\text{S}_2]}{[\text{H}_2\text{S}]^2}$$

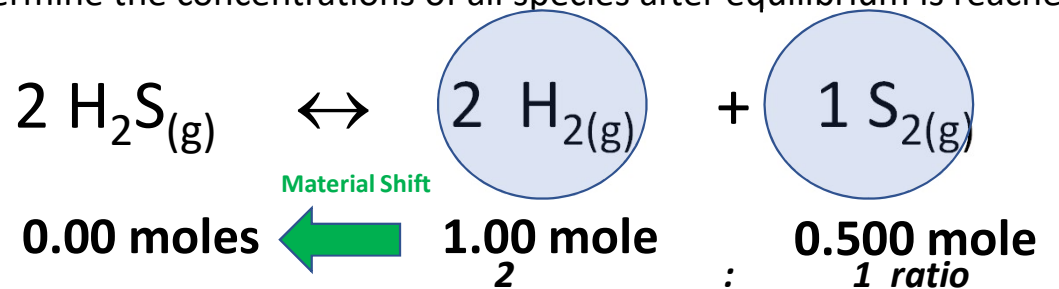
$$\frac{(4.37_{08} \times 10^{-3})^2 (2.18_{54} \times 10^{-3})}{(0.496)^2}$$

$$= 1.69_{96} \times 10^{-7} = K_C \quad \text{😊}$$

## 2. Material Shift Required

1.00 mole of  $\text{H}_2$  gas and 0.500 mole  $\text{S}_2$  are placed in a closed 2.00 liter container. Assume that no  $\text{H}_2\text{S}$  is originally present and determine the concentrations of all species after equilibrium is reached.

Reactants!



$$K_c = 1.67 \times 10^{-7}$$

Small  $K_c \Rightarrow$  Favors Reactants

Initially, only products are present.

Shifts *strongly* to the left (reactants).

Can't use  $X \sim 0$  assumption.

Nasty math ahead.

Material Shift:  
Convert product to reactant

<b>Material Shift</b>	<b>+1.00 mole</b>	<b>- 1.00 mole</b>		<b>- 0.500 mole</b>
<b>Final Moles</b>	<b>1.00 moles</b>	<b>0.00 moles</b>		<b>0.00 moles</b>

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<b>Initial</b>	1.00mol/2.00L <b>0.500 M</b>	<b>0.000 M</b>	<b>0.000 M</b>
	$[\text{H}_2\text{S}]_{\text{eq}} = 0.496\text{M}$	$[\text{H}_2]_{\text{eq}} = 4.37_{08} \times 10^{-3} \text{ M}$	$[\text{S}_2]_{\text{eq}} = 2.18_{54} \times 10^{-3} \text{ M}$

Same as problem 1 previously solved using  $X \sim 0$  assumption.

