

Species	[Equilibrium]
PCl_5	x
PCl_3	$0.100 - x$
Cl_2	$0.100 - x$

Solving the quadratic equation gives us two possible values for 'x':

$$x = 0.157 \text{ or } x = 0.0639$$

Which is correct for this equilibrium?

$x = 0.157$ does not work, because it would give negative concentrations for phosphorus trichloride and chlorine gas, which is not possible!

$$x = 0.0639$$

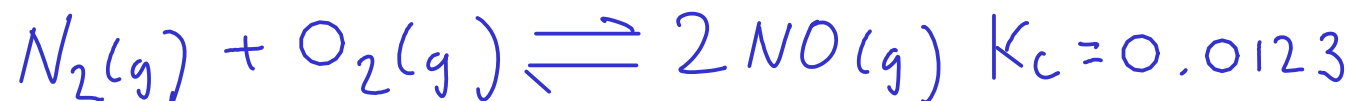
$$[\text{PCl}_5] = x = 0.0639 \text{ M PCl}_5$$

$$[\text{PCl}_3] = 0.100 - x = 0.036 \text{ M PCl}_3$$

$$[\text{Cl}_2] = 0.100 - x = 0.036 \text{ M Cl}_2$$

These concentrations look reasonable given that $K_c = 49$ (large enough for us to expect a greater amount of product at equilibrium).

An 8.00 L reaction vessel at 3900C is charged with 0.850 mol of nitrogen and oxygen gases. Find the concentration of all species at equilibrium.



$$K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]} = 0.0123$$

Set up a chart to reduce the number of variables

Species	[Initial]	Δ	[Equilibrium]
N_2	$\frac{0.850 \text{ mol}}{8.00 \text{ L}} = 0.10625$	$-x$	$0.10625 - x$
O_2	$\frac{0.850 \text{ mol}}{8.00 \text{ L}} = 0.10625$	$-x$	$0.10625 - x$
NO	0	$+2x$	$2x$

Define "x" as the change in nitrogen gas concentration.

Plug the equilibrium expressions into the K_c equation:

$$\frac{(2x)^2}{(0.10625 - x)(0.10625 - x)} = 0.0123$$

Solve for "x" ...

$$\frac{(2x)^2}{(0.10625 - x)(0.10625 - x)} = 0.0123$$

$$\sqrt{\frac{(2x)^2}{(0.10625 - x)^2}} = \sqrt{0.0123}$$

Can be solved as a quadratic, OR ...
take the square root of both sides.

$$\frac{2x}{0.10625 - x} = 0.1109053651$$

$$2x = 0.011783695 - 0.1109053651x$$

$$2.1109053651x = 0.011783695$$

$$x = 0.00558$$

Plug back into the equilibrium expressions from earlier.

$$[N_2] = 0.10625 - x = 0.101 \text{ M } N_2$$

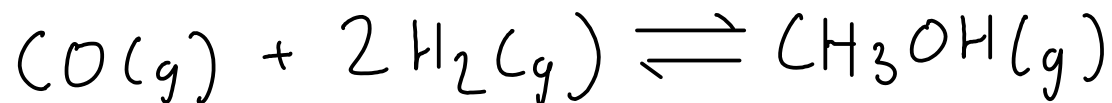
$$[O_2] = 0.10625 - x = 0.101 \text{ M } O_2$$

$$[NO] = 2x = 0.0112 \text{ M } NO$$

Species	[Equilibrium]
N_2	$0.10625 - x$
O_2	$0.10625 - x$
NO	$2x$

Concentrations look reasonable given $K_c = 0.0123$ (little product should be made)

- Pressure can affect a GAS-PHASE equilibrium ... sometimes. How?

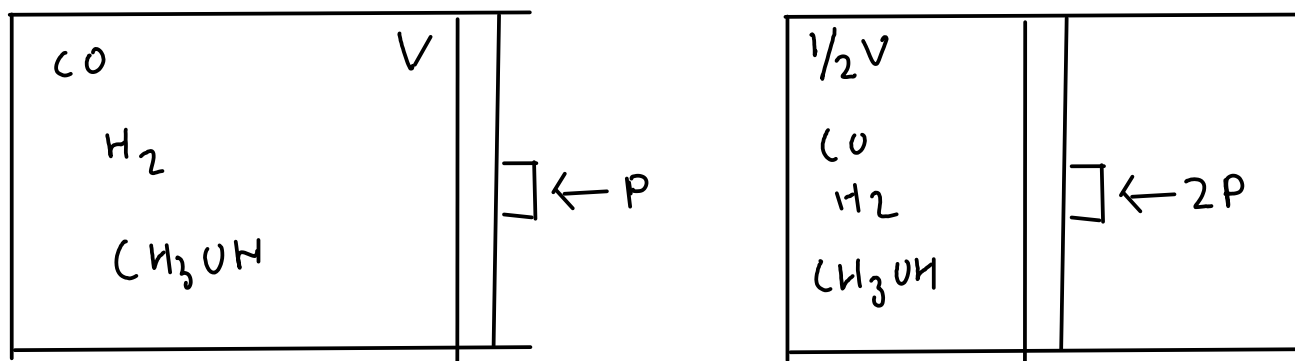


... how might pressure affect this equilibrium?

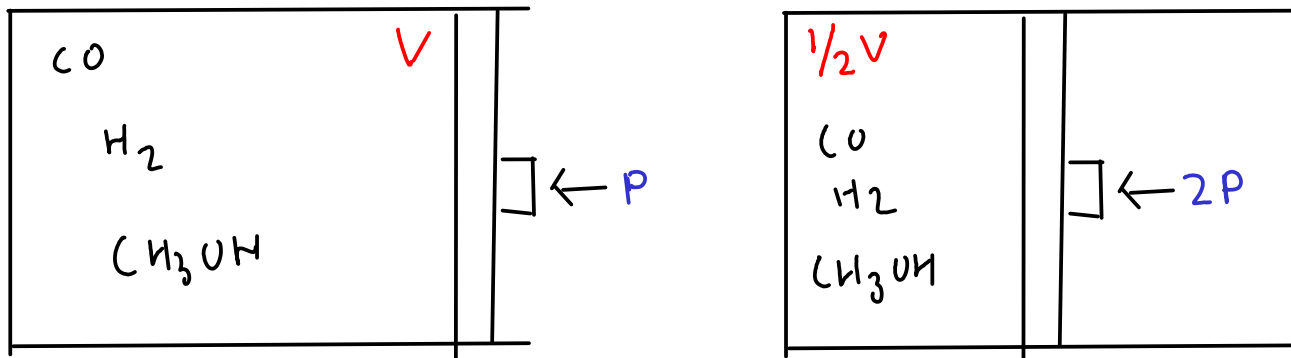
- If the change in pressure CHANGES CONCENTRATIONS, then this equilibrium would be disturbed and Le Chateleur's Principle would apply.

- Adding an INERT GAS would change pressure, but would it change concentration of the gases? NO - so addition of argon would have no effect on the equilibrium!

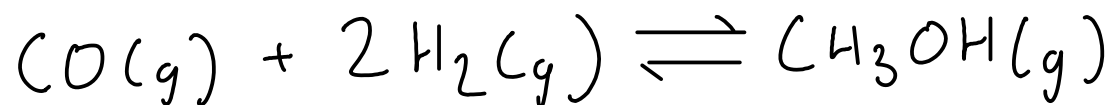
- What about COMPRESSION?



... compression increases pressure by DECREASING total volume.



... but this volume change affects ALL concentrations the same way. In this example, each concentration is DOUBLED.



$$K_c = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}][\text{H}_2]^2} = \frac{(1)}{(1)(1)^2} = 1$$

For simplicity,
let's assume
 $K_c = 1$, and all
concs = 1M

Doubling
concentrations
gives $Q =$

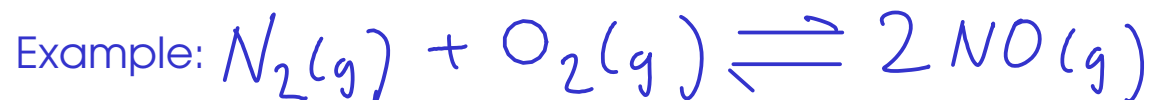
$$\frac{2}{(2)(2)^2} = \frac{1}{4}$$

$Q < K_c$, so equilibrium shifts to the RIGHT, forming more methanol at the expense of hydrogen and carbon monoxide.

In general, compressing an equilibrium reaction in the gas phase will cause the equilibrium to shift towards the side with fewer moles of gas. This causes the pressure to decrease.

In general, decompressing an equilibrium reaction in the gas phase will cause the equilibrium to shift towards the side with more moles of gas. This causes the pressure to increase.

HOWEVER, this can only be true IF there's a side of the reaction with more moles of gas than the other. If both sides of the reaction have the SAME number of moles of gas, then a pressure change will NOT affect the equilibrium.



... would not respond to a pressure change.

¹⁰¹ FACTORS THAT MAY AFFECT EQUILIBRIUM

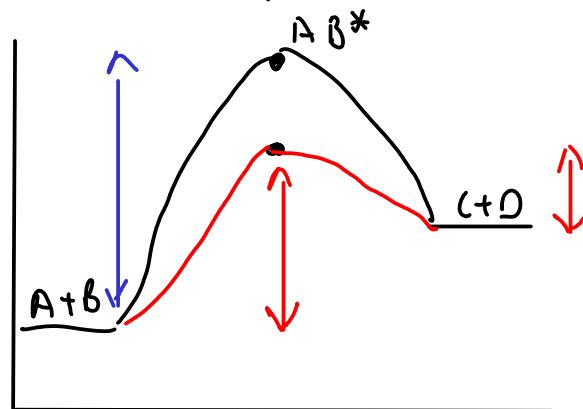
① TEMPERATURE (effect depends on whether reaction is endothermic or exothermic)

- Changes rate of reaction, too!
- ... changes K_c

② PRESSURE - only for gas-phase reactions which have different numbers of moles of gas on each side of the equilibrium. Otherwise, no effect.

- ... no change of K_c

③ CATALYSTS - do NOT affect equilibrium, but make the equilibrium state occur more quickly.



The catalyst raises BOTH forward and reverse rates, so it doesn't affect the composition of the equilibrium mixture!

④ CONCENTRATION - Le Chateleur's Principle applies for changing concentrations. An equilibrium will shift to counteract a change in concentration of reactant or product.

- ... doesn't change K_c .