02/11/19

Finding and using 'K'

* Pure solids and liquids don't appear in K, only solutions and gases *

* $K_p = K_c (RT)^{\Delta n}$

A) Reversing A RXN:

equilibrium expression

$2\,NO_{(g)} + Br_{2\,(g)} \rightleftharpoons 2\,NOBr_{(g)}$ $\quad K_f = \dfrac{[NOBr]^2}{[NO]^2[Br_2]}$

$2\,NOBr_{(g)} \rightleftharpoons 2\,NO_{(g)} + Br_{2\,(g)}$

$\therefore \boxed{K_r = \dfrac{1}{K_f}}$ ⊛ The K_r for a reverse rxn is the reciprocal of the fwd rxn.

$K_r = \dfrac{[NO]^2[Br_2]}{[NOBr]^2}$

reverse RXN

B) Multiplying coefficients:

$2\,NO_{(g)} + Br_{2\,(g)} \rightleftharpoons 2\,NOBr_{(g)}$ $\quad K_{f_1} = \dfrac{[NOBr]^2}{[NO]^2[Br_2]}$

$4\,NO + 2\,Br_2 \rightleftharpoons 4\,NOBr$

$K_{f_2} = \dfrac{[NOBr]^4}{[NO]^4[Br_2]^2}$

⊛ If we multiply a rxn coefficient by a factor, we raise K to that power

$\boxed{K_{f_2} = (K_{f_1})^2}$

C) Adding Two RXNs

$N_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2\,NO_{(g)} \quad K_c = 7.2 \cdot 10^{-9}$

$2\,NO_{(g)} + O_{2\,(g)} \rightleftharpoons 2\,NO_{2\,(g)} \quad K_c = 0.020$

what is K_c for:

$N_{2\,(g)} + 2\,O_{2\,(g)} \rightleftharpoons 2\,NO_{2\,(g)}$

$K_1 = \dfrac{[NO]^2}{[N_2][O_2]} + K_2 = \dfrac{[NO_2]^2}{[NO]^2[O_2]} \Rightarrow K_{1+2} = \dfrac{[NO_2]^2}{[N_2][O_2]^2} \therefore K_1 \cdot K_2$

⊛ When you add two rxns, the K for the overall rxn is the product of the Ks for the individual rxn.

CLASS DEMO: 02/11/19

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

PINK BLUE

↳ temperature changes equilibrium

Calculating K

(1)

$2\,BrCl_{(g)} \rightleftharpoons Br_{2\,(g)} + Cl_{2\,(g)}$

• initially the vessel is charged at 500 K w/ BrCl (g) at a partial pressure of 0.500 atm. At equilibrium, the BrCl partial pressure is 0.040 atm. Calculate the value of Kp at 500 K.

$$\left\{ K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2} \qquad K_p = \frac{P_{Br_2} P_{Cl_2}}{P_{BrCl}^2} \right\}$$ must know equilibrium values

• USE RICE (or) ICE TABLES → R (Rxn) I (Initial) C (Change) E (Equilibrium)

R	$2\,BrCl \rightleftharpoons$	Br_2 +	Cl_2
I	0.500 atm	0 atm	0 atm
C	−0.460 atm	+0.23 atm	+0.23 atm
E	0.040 atm	0.23 atm	0.23 atm

PV = nRT

'p' proportional to 'n' in constant temp ~~[illegible]~~.

$0.460\ \cancel{atm}\ BrCl \times \frac{1\ atm\ Br_2}{\cancel{2\ atm}\ BrCl} = 0.230\ atm$

$$K_p = \frac{P_{Br_2} P_{Cl_2}}{P_{BrCl}^2} = \frac{(0.230)(0.230)}{(0.460)^2} = \boxed{33}$$

expected b/c more products than reactants.

STEPS to Find 'K'

1) Tabulate knowns in RICE
2) Calculate the known concentrations changes
3) Use stoichiometry
4) Use changes and initials to calculate equilibrium concentrations
5) Use equilibrium concentrations to find 'K'

② What if no equilibrium concentrations are known?

$$PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_{2\,(g)}$$

The equilibrium constant K_p is 0.497 at 500 K. A gas cylinder at 500 K is charged w/ $PCl_5\,(g)$ at 1.66 atm. What are the equilibrium pressures of PCl_5, PCl_3, Cl_2 at said temp?

$$K_p = \frac{P_{Cl_3}\,P_{Cl_2}}{P_{PCl_5}} = \frac{X \cdot X}{(1.66 - X)} = 0.497$$

Substitute

R	PCl_5 ⇌	PCl_3 +	Cl_2
I	1.66 atm	0	0
C	$-X$	$+X$	$+X$
E	$1.66 - X$	X	X
	$\underbrace{1.66 - 0.693}_{0.967}$	0.693	0.693

assigned variable 'x'

$$\frac{X^2}{1.66 - X} = 0.497$$

$$X^2 = 0.497\,(1.66 - X)$$

$$X^2 + 0.497X - 0.825 = 0$$

Method #1: Quadratic Formula

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$X_1 = -1.19$, $\boxed{X_2 = 0.693}$

Reject