Name: Key
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Chemistry 12
EQUILIBRIUM Lesson #6
THE EQUILIBRIUM EXPRESSION AND K_{eq}

Given the following **EQUILIBRIUM EQUATION**:

$$aA\,(g) + bB\,(g) \longleftrightarrow cC\,(g) + dD\,(g)$$

where the lower case letters represent coefficients and the upper case letters represent chemical species

We can write out an **EQUILIBIUM EXPRESSION** (aka K_{eq}) the numerical value of the K_{eq} is called the EQUILIBRIUM CONSTANT

The equlibrium expression is conventionally written as:

[PRODUCTS]/[REACTANTS]

Therefore the above generic equation is written as:

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Write the following examples out as **EQUILIBIUM EXPRESSIONS** :

a. $PCl_3\,(g) + Cl_2\,(g) \longleftrightarrow PCl_5\,(g)$

$K_{eq} = \frac{[PCl_5]}{[PCl_3][Cl_2]}$

b. $H_2\,(g) + F_2\,(g) \longleftrightarrow 2\,HF\,(g)$

$K_{eq} = \frac{[HF]^2}{[H_2][F_2]}$

c. $2HBr\,(g) \longleftrightarrow H_2\,(g) + Br_2\,(g)$

$K_{eq} = \frac{[H_2][Br_2]}{[HBr]^2}$

NOTICE THAT THE ABOVE CHEMICALS ARE ALL IN THEIR GASEOUS **PHASES**! THIS IS IMPORTANT BECAUSE GENERALLY ONLY GASES AND AQUEOUS SPECIES ARE INCLUDED IN THE EQUILIBRIUM EXPRESSION

WHY? K_{eq} only includes species whose *concentrations* can CHANGE:

SOLIDS cannot be appreciably compressed (volume can't be decreased) therefore they cannot change their MOLAR CONCENTRATIONS (mol/L). This is why SOLIDS are NOT included in the K_{eq} expression

ex. $CaF_2\,(s) \longleftrightarrow Ca^{2+}\,(aq) + 2\,F^-\,(aq)$

$K_{eq} = \frac{[Ca^{2+}][F^-]^2}{1}$ or $K_{eq} = [Ca^{2+}][F^-]^2$

LIQUIDS also cannot be appreciably compressed. HOWEVER, if there is ANOTHER LIQUID present it CAN cause both liquids to become DILUTE and, therefore, change both liquid's concentrations. This is why if the balanced equilibrium equation contains a SINGLE liquid it is NOT included in the K_{eq} expression.

ex. Br_2 (l) + H_2 (g) <-----> 2 HBr (g)

$K_{eq} = \frac{[HBr]^2}{[H_2]}$

ex. CH_3COOH (l) + Cl_2 (g) <----> CH_3COCH_2 (l) + HCl (g)

$K_{eq} = \frac{[CH_3COCH_2][HCl]}{[CH_3COOH][Cl_2]}$

ex. Cl_2 (g) + 8 H_2O (l) <----> $Cl_2 \cdot 8H_2O$ (s)

$K_{eq} = \frac{1}{[Cl_2]}$

TO SUMMARIZE: Because the concentrations of solids and pure liquids cannot change, adding them as a reactant or product to a system in equilibrium will have NO EFFECT. That is, the equilibrium does NOT SHIFT. THEREFORE; when writing a K_{eq} expression, solids and SINGLE liquids are NEVER included whereas gases, aqueous and multiple liquids are.

SEAT WORK/HOMEWORK: Exercises 31- 35
PLO's: F2

Solve the Keq for PCl_5 in this keq expression

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

$K_{eq} = \frac{[PCl_5]}{[PCl_3][Cl_2]} \times [PCl_3][Cl_2]$

$[PCl_3][Cl_2]\,K_{eq} = [PCl_5]$