Name Key Grade___/10

Rice Box Equilibrium Problems

1. Gaseous hydrogen iodide is placed in a closed container at 425°C, where it partially decomposes to hydrogen and iodine: $2\ HI(g) \leftrightarrow H_2(g) + I_2(g)$. At equilibrium it is found that $[HI] = 3.53 \times 10^{-3}$ M, $[H_2] = 4.79 \times 10^{-4}$ M, and $[I_2] = 4.79 \times 10^{-4}$ M. What is the value of Keq at this temperature?

Reaction	$2HI \rightleftharpoons H_2 + I_2$
Initial	
Change	
Equilibrium	3.53×10^{-3} 4.79×10^{-4} 4.79×10^{-4}

$$K_c = \frac{[H_2][I_2]}{[HI]^2} = \frac{(4.79\times10^{-4})(4.79\times10^{-4})}{(3.53\times10^{-3})^2} = \frac{2.29\times10^{-7}}{1.246\times10^{-5}} = 0.0184$$

2. A closed system initially containing 1.00×10^{-3} M H_2 and 2.00×10^{-3} M of I_2 at 448 °C is allowed to reach equilibrium. Analysis of the equilibrium mixture shows that the concentration of HI is 1.87×10^{-3} M. Calculate the Keq at 488°C for the reaction: $H_2(g) + I_2(g) \leftrightarrow 2\ HI\ (g)$.

$x = 0.000935$

Reaction	$H_2 + I_2 \rightleftharpoons 2HI$
Initial	1×10^{-3} 2×10^{-3} 0
Change	$-x$ $-x$ $+2x$
Equilibrium	0.000065 0.00107 1.87×10^{-3}

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{(.00187)^2}{(0.000065)(0.00107)} = \frac{3.49\times10^{-6}}{7\times10^{-8}} = 49.95$$

3. Sulfur trioxide decomposed at high temperature in a sealed container: $2SO_3(g) \leftrightarrow 2SO_2(g) + O_2(g)$. The initial concentration of $SO_3(g)$ is 6.1×10^{-3} M. At equilibrium the concentration of $SO_3(g)$ is 2.4×10^{-3} M. Calculate the Keq.

Reaction	$2SO_3 \rightleftharpoons 2SO_2 + O_2$
Initial	6.1×10^{-3}
Change	$-2x$ $+2x$ $+x$
Equilibrium	2.4×10^{-3} 0.0037 0.00185

$0.0061 - 2x = 0.0024$

$x = 0.00185$

$$K_c = \frac{[SO_2]^2[O_2]}{[SO_3]^2} = \frac{(0.0037)^2(0.00185)}{(.0024)^2} = \frac{2.5\times10^{-8}}{5.76\times10^{-6}} = 0.00434$$

4. A mixture of 0.10 mol of NO, 0.050 mol of H_2, and 0.10 mol of H_2O is placed in a 1.0 L vessel at 300 K. The following equilibrium is established: $2NO(g) + 2H_2(g) \leftrightarrow N_2(g) + 2H_2O(g)$ at equilibrium [NO] = 0.062M. Calculate the equilibrium concentrations of H_2, N_2, H_2O, and Keq.

Reaction	$2NO +$	$2H_2 \rightleftharpoons$	$N_2 +$	$2H_2O$
Initial	0.10	0.050		0.10
Change	−2x	−2x	+x	+2x
Equilibrium	0.062	0.012	0.019	0.038

$0.10 - 2x = 0.062$

$-2x = -0.038$

$x = 0.019$

$$Keq = \frac{[H_2O]^2[N_2]}{[H_2]^2[NO]^2} = \frac{(0.038)^2(0.019)}{(0.012)^2(0.062)^2} = \frac{0.000027436}{0.000000554} = 49.55$$

5. A mixture of 0.687 mol H_2 and 0.439 mol of Br_2 is heated in a 2.00 L vessel at 700K. These substances react as follows: $H_2(g) + Br_2(g) \leftrightarrow 2\,HBr(g)$. At equilibrium the vessel is found to contain 0.566 g of H_2. Calculate the equilibrium concentrations of the reactants, product, and the Keq.

Reaction	$H_2 +$	$Br_2 \rightleftharpoons$	$2HBr$
Initial	0.3435	0.2195	0
Change	−x	−x	+2x
Equilibrium	0.14	0.0165	0.406

$0.3435 - x = 0.14$

$-x = -0.203$

$x = 0.203$

$$K_c = \frac{[HBr]^2}{[H_2][Br_2]} = \frac{(0.406)^2}{(.0165)(0.14)} = \frac{0.164836}{0.00231} = 71.36$$