PROBLEMAS DE EQUILIBRIO PAU (1)

1. $SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2} O_2(g)$ $\quad \alpha = 0,4$

$C_0(1-\alpha) \qquad C_0\alpha \qquad \frac{C_0\alpha}{2}$

a) $C_{tot} = C_0(1-\alpha) + C_0\alpha + C_0\frac{\alpha}{2} = C_0\left(1+\frac{\alpha}{2}\right) = 1,2\,C_0$

$$X_{SO_3} = \frac{C_0(1-\alpha)}{C_0\left(1+\frac{\alpha}{2}\right)} = \frac{0,6}{1,2} = \frac{1}{2}$$

$$X_{SO_2} = \frac{C_0\alpha}{C_0\left(1+\frac{\alpha}{2}\right)} = \frac{0,4}{1,2} = \frac{1}{3}$$

$$X_{O_2} = \frac{C_0\frac{\alpha}{2}}{C_0\left(1+\frac{\alpha}{2}\right)} = \frac{0,2}{1,2} = \frac{1}{6}$$

b) $P_{SO_3} = P_{tot} \cdot X_{SO_3} = 100 \times 0,5 = 50$ atm.

$P_{SO_2} = 33'3$ atm, $P_{O_2} = 16.\hat{6}$ atm.

$$K_p = \frac{P_{SO_2} \cdot P_{O_2}^{\frac{1}{2}}}{P_{SO_3}} = 2.72$$

2. $2\,HI \rightleftharpoons I_2 + H_2$

$0,4-x \qquad \frac{x}{2} \qquad \frac{x}{2}$

a) $n_{total} = 0,4 - x + \frac{x}{2} + \frac{x}{2} = 0,4$

$X_{HI} = 0,8 \Rightarrow n_{HI} = 0,8 \cdot 0,4 = 0,32$ mol

$X_{I_2} = X_{H_2} = 0,1 \Rightarrow n_{I_2} = n_{H_2} = 0.04$ mol

$[HI] = \frac{0,32}{1.6} = 0,2\,M$

$[I_2] = [H_2] = 0.025\,M$

$$K_c = \frac{|I_2|\,|H_2|}{|HI|^2} = \frac{(0.025)^2}{(0.2)^2} = 1.56 \times 10^{-2}$$

b) $P_T = \frac{nRT}{V} = \frac{0.4 \times 0.082 \times 673}{1.6} = 13.80$ atm.

$P_{HI} = 0,8 \times 13.80 = 11.04$ atm.

$P_{I_2} = P_{H_2} = 0,1 \times 13,80 = 1.38$ atm.

3. $N_2O_4 \rightleftharpoons 2NO_2 \quad K_{250} = 4,6 \times 10^{-3}$

2,3 g N_2O_4 $\xrightarrow{\div 92\ g/mol}$ 0,025 mol N_2O_4

$[N_2O_4]_0 = \frac{0,025}{0,5} = 0,05\ M$

$K_c = 4,6 \times 10^{-3} = \frac{x^2}{0.05 - x} \Rightarrow x^2 + 4,6 \times 10^{-3} x - 2,3 \times 10^{-4} = 0$

$x = \frac{-4,6 \times 10^{-3} \pm \sqrt{(4,6 \times 10^{-3})^2 + 4 \times 2,3 \times 10^{-4}}}{2} = \begin{cases} \nearrow 0,013\ M \\ \searrow < 0 \ \times \end{cases}$ ($\sqrt{\ } \nearrow 3,06 \times 10^{-2}$)

$n_{N_2O_4} = 0,025 - \frac{0,013}{2} = 0,0185$ mol $\xrightarrow{\times 92\ g/mol}$ 1,70 g N_2O_4

$m_{N_2O_4} = 1.70$ g ; $m_{NO_2} = m_T - m_{N_2O_4} = 2,3 - 1,7 = 0,6$ g NO_2

4. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

a) Reaccionan 5% moles $N_2 = 0,05 \times 2,5 = 0,125$ moles $\Rightarrow$ quedan sin reaccionar $2,5 - 0,125 = 2.375$ mol N_2

Reaccionan $3 \times 0,125 = 0,375$ moles $H_2 \Rightarrow$ quedan $2,5 - 0,375 = 2,125$ mol H_2

Se producen $0,125 \times 2 = 0,250$ moles NH_3

$K_c = \frac{\left(\frac{0,250}{25}\right)^2}{\left(\frac{2,375}{25}\right)\left(\frac{2.125}{25}\right)^3} = 1.71$

$K_p = K_c \cdot (RT)^{-2} = 1.71 \times (0,082 \times 673)^{-2} = 5.61 \times 10^{-4}$

4.- b) $n_T = 2,375 + 2.125 + 0.250 = 4.75$ mol

$P_t = \frac{nRT}{V} = 10,485$ atm.

$P_{N_2} = X_{N_2} \cdot P_T = \frac{2,375}{4.75} \times 10.485 = 5,24$ atm.

$P_{H_2} = X_{H_2} \cdot P_T = 4.69$ atm

$P_{NH_3} = X_{NH_3} \cdot P_T = 0,55$ atm.

5.- $H_2(g) + CO_2(g) \rightleftharpoons CO(g) + H_2O(g)$

inicio: 0,85 mol 0,85 mol

equi: 0,85 − 0,55 = 0,3 mol 0,3 mol 0,55 mol 0,55 mol

a) $n_{mols} = 0.3 + 0,3 + 0.55 + 0,55 = 1.7$ mol.

$P_t = \frac{n_T \cdot RT}{V} = \frac{1.7 \times 0.082 \times 1873}{5} = 52,22$ atm.

$P_{H_2} = P_{CO_2} = X_{H_2} \cdot P_T = \frac{0.3}{1.7} \times P_T = 9.215$ atm

$P_{CO} = P_{H_2O} = X_{CO} \cdot P_T = \frac{0.55}{1.7} \times P_T = 16,895$ atm.

b) $K_c = \frac{(0,55)^2}{(0.3)^2} = 3.36$

$H_2(g) + CO_2(g) \rightleftharpoons CO(g) + H_2O(g)$

$0.33 + x$ $0.33 + x$ $0.95 - x$ $0.55 - x$

$$3.36 = \frac{(0.95-x)(0.55-x)}{(0.33+x)^2}$$

$$2.26\,x^2 + 3,7126\,x - 0,1566 = 0$$

$$x = \frac{-3,7126 \pm \sqrt{(3,7126)^2 + 4 \times 2,26 \times 0,1566}}{2 \times 2,26} = \frac{3,8986}{}$$

→ < 0 ✗

→ 0.04115 mol.

$$[H_2] = [CO_2] = \frac{0,33 + 0,04115}{5} = 0,07423\ M$$

$$[CO] = \frac{0,95 - 0,04115}{5} = 0,1818\ M$$

$$[H_2O] = \frac{0,55 - 0,04115}{5} = 0,1018\ M$$

6.

$$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2} O_2(g)$$

72 g

$\downarrow \div M = 80\ g/mol$

0,9 mol

$\downarrow \div 2,5\ l$

0,36 M

$0,36 - x$	x	$\frac{x}{2}$

$$n_T = 0,36 - x + x + \frac{x}{2} = 0,36 + \frac{x}{2}$$

$$n_T = \frac{PV}{RT} = \frac{18 \times 2,5}{0,082 \times 473} = 1,16\ mol$$

$$1,16 = 2,5 \cdot \left(0,36 + \frac{x}{2}\right) = 0,9 + 1,25x \Rightarrow x = 0,208\ M$$

$$K_c = \frac{0,208 \times \left(\frac{0,208}{2}\right)^{\frac{1}{2}}}{0,36 - 0,208} = 0,4413$$

$$K_p = K_c (RT)^{\frac{1}{2}} = 2,75$$

7. $$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) \qquad K_p(250°C) = 1,05$$

$$P_{PCl_5} = \frac{0,042 \times 0,082 \times 523}{2} = 0,9006$$

$$P_{PCl_3} = \frac{0,023 \times 0,082 \times 523}{2} = 0,4932$$

$$K_p = 1,05 = \frac{0,4932 \times P_{Cl_2}}{0,9006} \Rightarrow P_{Cl_2} = 1,92\ atm$$

8. $I_2(g) \rightleftharpoons 2I(g)$ $\quad K_c(1000\,K) = 3{,}76\times10^{-5}$

$|I_2| = 0{,}5\ M \qquad |I| = 2{,}5\times10^{-3}\ M$

$Q = \dfrac{|I|^2}{|I_2|} = 1{,}25\times10^{-5} < K_c \Rightarrow$ la reacción se desplaza hacia la dcha

$|I_2|_e = 0{,}5 - x \qquad |I|_e = 2{,}5\cdot10^{-3} + 2x$

$3{,}76\times10^{-5} = \dfrac{(2{,}5\times10^{-3}+2x)^2}{0{,}5-x}$

$4x^2 + 1{,}00376\times10^{-2}x - 1{,}255\times10^{-5} = 0$

$x = \dfrac{-1{,}00376\times10^{-2} \pm \sqrt{(1{,}00376\times10^{-2})^2 + 4\times4\times1{,}255\times10^{-5}}}{8} = \begin{cases} < 0 \ \times \\ 9{,}1596\times10^{-4}\ M \end{cases}$ (1.7365×10⁻²)

$|I_2| = 0{,}5 - x = 0{,}499\ M$

$|I| = 4{,}33\times10^{-3}\ M$

9. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ $\quad K_c(760\,K) = 33{,}3$

1,5 g → ÷ M = 208,5 g/mol → $7{,}19\times10^{-3}$ mol → ÷ 0,0363 l → 0,198 M

15 g → ÷ M = 137,5 g/mol → 0,109 mol → ÷ 0,0363 l → 3,01 M

PCl_5	PCl_3	Cl_2
$0{,}198 - x$	$3{,}01 + x$	x

$33{,}3 = \dfrac{(3{,}01+x)\,x}{0{,}198-x} \Rightarrow 6{,}593 - 33{,}3x = 3{,}01x + x^2$

$x^2 + 36{,}31x - 6{,}593 = 0$

$x = \dfrac{-36{,}31 \pm \sqrt{(36{,}31)^2 + 4\times6{,}593}}{2} = \begin{cases} < 0 \ \times \\ 0{,}1807\ M \simeq 0{,}181\ M \end{cases}$ (36,67)

$[PCl_5] = 0{,}017\ M$

$|PCl_3| = 3{,}181\ M$

$|Cl_2| = 0{,}181\ M$

10. $CO_2(g) + H_2S(g) \rightleftharpoons COS(g) + H_2O(g)$

	4.4 g			
	=			
	0,1 mol	n_0	—	—
equilibrio:	0.1 − 0.01 = 0.09	$n - 0.01$	0.01	0.01

a) $n_T = 0.09 + n_0 - 0.01 + 0.01 + 0.01 = n + 0.1$

$n_T = \frac{PV}{RT} = 0.499$ mol.

$0.499 = n_0 + 0,1 \Rightarrow n_0 = 0,399$ mol

En el equilibrio hay: 0,09 mols CO_2, 0,399 mol H_2S, 0,01 mol de COS y 0,01 gmol de H_2O.

b) $K_p = K_c \cdot (RT)^{\Delta n = 0} = K_c = \frac{0.01 \cdot 0.01}{0.09 \cdot 0.389} = 2,86 \times 10^{-3}$

11. $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$ $\quad K_c(2000K) = 4.40$

1 mol	1 mol	1 mol	—
$1 - x$	$1 - x$	$1 + x$	x

$4,40 = \frac{(1+x) \cdot x}{(1-x)^2}$

$3.40x^2 + 9.8x + 4.40 = 0$ ← 6.0166

$x = \frac{9.8 \pm \sqrt{9.8^2 - 4 \cdot 4.40 \cdot 3.40}}{6,8} = \begin{cases} 0,556 \\ 2,326 > 1 \ \times \end{cases}$

$n_{H_2} = n_{CO_2} = 1 - x = 0.444 \Rightarrow |H_2| = |CO_2| = 9,49 \times 10^{-2} M$

$n_{H_2O} = 1 + x = 1.556 \Rightarrow |H_2O| = 0,332 M$

$n_{CO} = x = 0.556 \Rightarrow |CO| = 0,119 M$

12. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

1 M	1 M	—
$1 - x$	$1 - x$	$2x$

a) $45.9 = \frac{(2x)^2}{(1-x)^2} \xrightarrow{\sqrt{\ }} 6.775 = \frac{2x}{1-x} \Rightarrow x = 0.772$ M

$[H_2] = [I_2] = 1 - x = 0,228$ M $\quad [HI] = 2x = 1.544$ M

Problemas de equilibrio PAU

12. b) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

$2{,}228 - x \quad 0{,}228 - x \quad 1.544 + 2x$

$$45.9 = \frac{(1.544+2x)^2}{(2{,}228-x)(0{,}228-x)}$$

$$41.9\,x^2 - 118.88\,x + 20.932 = 0 \quad \swarrow 102{,}07$$

$$x = \frac{118.88 \pm \sqrt{(118.88)^2 - 4\times 41.9 \times 20.932}}{2\times 41.9} = \begin{cases} 0.189\ M \\ 2.649\ M > 0.228\ M\ \times \end{cases}$$

$[H_2] = 2.228 - x = \underline{2.039\ M}$

$[I_2] = 0{,}228 - x = \underline{0.039\ M}$

$[HI] = 1.544 + 2x = \underline{1.922\ M}$

13. $H_2O(g) + CO(g) \rightleftharpoons CO_2(g) + H_2(g)$ $\quad V = 1\ l$

$0{,}20 \quad 0{,}20 \quad 0{,}40 \quad 0.40$

$$K_c = \frac{(0{,}40)^2}{(0.20)^2} = 4$$

Se añaden 0,4 mols CO_2 y CO $\Rightarrow$ $|CO| = |CO_2| =$

$$Q = \frac{0{,}4 \times 0{,}8}{0{,}2 \times 0{,}6} = 2{,}67 < 4 \Rightarrow$$ la reacción se desplaza a la dcha.

$$4 = \frac{(0{,}8+x)\,(0{,}4+x)}{(0.2-x)\,(0.6-x)}$$

$$3x^2 - 4.4\,x + 0{,}16 = 0 \quad \swarrow 4{,}1761$$

$$x = \frac{4.4 \pm \sqrt{4.4^2 - 4\times 3 \times 0.16}}{6} = \begin{cases} 0.0373\ M \\ 3.429\ M > 0{,}2\ M\ \times \end{cases}$$

$\boxed{[CO] = 0{,}6 - x = \underline{0{,}563\ M}}$