



K_p PROBLEMS

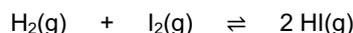
- 1) 1.000 moles of PCl₅ vapour are heated to 500 K in a sealed vessel. The equilibrium mixture, at a pressure of 625 kPa, contains 0.600 moles of chlorine. Calculate K_p.



initial moles	1.000			
change	-0.600	+0.600	+0.600	
equilibrium moles	0.400	0.600	0.600	total moles = 1.600
mole fraction	$\frac{0.400}{1.600}$	$\frac{0.600}{1.600}$	$\frac{0.600}{1.600}$	total of mole fractions = 1
partial pressures	$\frac{1.400}{2.600} \times 625$	$\frac{0.600}{2.600} \times 625$	$\frac{0.600}{2.600} \times 625$	
partial pressures	156.25 kPa	234.375 kPa	234.375 kPa	total of partial pressures = 500 kPa

$$K_p = \frac{(p\text{PCl}_3)(p\text{Cl}_2)}{(p\text{PCl}_5)} = \frac{(234.375)^2}{(156.25)} = 352 \text{ kPa (3sf)}$$

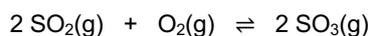
- 2) A mixture of 1.90 moles of H₂ and 1.90 moles of I₂ were allowed to reach equilibrium at 710 K. The equilibrium mixture was found to contain 3.00 moles of HI. Calculate K_p.



initial moles	1.90	1.90		
change	-1.50	-1.50	+3.00	
equilibrium moles	0.40	0.40	3.00	total moles = 3.80
mole fraction	$\frac{0.40}{3.80}$	$\frac{0.40}{3.80}$	$\frac{3.00}{3.80}$	total of mole fractions = 1
partial pressures	$\frac{0.40}{3.80} \times P$	$\frac{0.40}{3.80} \times P$	$\frac{3.00}{3.80} \times P$	
partial pressures	0.1053 P	0.1053 P	0.7895 P	total of partial pressures = 1.00 P

$$K_p = \frac{(p\text{HI})^2}{(p\text{H}_2)(p\text{I}_2)} = \frac{(0.7895 P)^2}{(0.1053 P)^2} = 56$$

- 3) For the equilibrium below calculate K_p if pO₂ = 102 kPa, pSO₂ = 251 kPa, pSO₃ = 508 kPa.



$$K_p = \frac{(p\text{SO}_3)^2}{(p\text{O}_2)(p\text{SO}_2)^2} = \frac{(508)^2}{(102)(251)^2} = 0.0402 \text{ kPa}^{-1}$$

- 4) 2.00 moles of sulphur dioxide and 1.00 mole of oxygen were mixed and allowed to reach equilibrium in the presence of a suitable catalyst under a total pressure of 500 kPa. At equilibrium, 0.67 moles of oxygen were present. Find K_p .

	$2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{SO}_3(\text{g})$			
initial moles	2.00	1.00		
change	-0.66	-0.33	+0.66	
equilibrium moles	1.34	0.67	0.66	total moles = 2.67
mole fraction	$\frac{1.34}{2.67}$	$\frac{0.67}{2.67}$	$\frac{0.66}{2.67}$	total of mole fractions = 1
partial pressures	$\frac{1.34}{2.67} \times 500$	$\frac{0.67}{2.67} \times 500$	$\frac{0.66}{2.67} \times 500$	
partial pressures	250.9 kPa	125.5 kPa	123.6 kPa	total of partial pressures = 500 kPa

$$K_p = \frac{(p\text{SO}_3)^2}{(p\text{O}_2)(p\text{SO}_2)^2} = \frac{(123.6)^2}{(125.5)(250.9)^2} = 0.00194 \text{ kPa}^{-1}$$

- 5) 2.00 moles of X was heated to a temperature of 2000°C until equilibrium was established under a total pressure of 80 MPa. At equilibrium, X was found to have undergone 20% dissociation. Calculate K_p .

	$\text{X}(\text{g}) \rightleftharpoons \text{Y}(\text{g}) + 2 \text{Z}(\text{g})$			
initial moles	2.00			
change	-0.40	+0.40	+0.80	
equilibrium moles	1.60	0.40	0.80	total moles = 2.80
mole fraction	$\frac{1.60}{2.80}$	$\frac{0.40}{2.80}$	$\frac{0.80}{2.80}$	total of mole fractions = 1
partial pressures	$\frac{1.60}{2.80} \times 80$	$\frac{0.40}{2.80} \times 80$	$\frac{0.80}{2.80} \times 80$	
partial pressures	45.71 MPa	11.43 MPa	22.86 MPa	total of partial pressures = 80 MPa

$$K_p = \frac{(pY)(pZ)^2}{(pX)} = \frac{(11.43)(22.86)^2}{(45.71)} = 131 \text{ MPa}^2$$

- 6) 2.00 moles of A was mixed with 2.00 moles of B and the mixture allowed to reach equilibrium at 500°C. The equilibrium mixture was found to contain 0.90 mole of A. Calculate K_p .

	$2 \text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons 3 \text{C}(\text{g})$			
initial moles	2.00	2.00		
change	-1.10	-0.55	+1.65	
equilibrium moles	0.90	1.45	1.65	total moles = 4.00
mole fraction	$\frac{0.90}{4.00}$	$\frac{1.45}{4.00}$	$\frac{1.10}{4.00}$	total of mole fractions = 1
partial pressures	$\frac{0.90}{4.00} \times P$	$\frac{1.45}{4.00} \times P$	$\frac{1.10}{4.00} \times P$	
partial pressures	0.225 P	0.3625 P	0.4125 P	total of partial pressures = P

$$K_p = \frac{(pC)^3}{(pA)^2 (pB)} = \frac{(0.4125P)^3}{(0.225P)^2 (0.3625P)} = 3.8$$

- 7) In the following reaction at 700 K, the amount of each gas present at equilibrium is 0.960 moles of NO₂, 0.040 moles of NO, and 0.020 moles of O₂. If K_p = 6.80 × 10⁻⁴ kPa, what must the total pressure have been to achieve this particular equilibrium mixture?



equilibrium moles	0.960	0.040	0.020	total moles = 1.020
mole fraction	$\frac{0.960}{1.020}$	$\frac{0.040}{1.020}$	$\frac{0.020}{1.020}$	total of mole fractions = 1
partial pressures	$\frac{0.960}{1.020} x P$	$\frac{0.040}{1.020} x P$	$\frac{0.020}{1.020} x P$	
partial pressures	0.9412P	0.0392P	0.0196P	

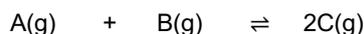
$$K_p = \frac{(p_{\text{O}_2}) (p_{\text{NO}})^2}{(p_{\text{NO}_2})^2}$$

$$6.80 \times 10^{-4} = \frac{(0.0196P) (0.0392P)^2}{(0.9412P)^2}$$

$$6.80 \times 10^{-4} = 3.40 \times 10^{-5} P$$

$$P = 20 \text{ kPa}$$

- 8) Calculate the number of moles of each species at equilibrium if 0.50 moles of A and 0.50 moles of B are mixed at 500 K, given that K_p = 2.55 at this temperature and pressure = P (you do **NOT** need to use a quadratic equation to solve this).



initial moles	0.50	0.50		
change	-x	-x	+2x	
equilibrium moles	0.50 - x	0.50 - x	2x	total moles = 1.00
mole fraction	$\frac{0.50-x}{1.00}$	$\frac{0.50-x}{1.00}$	$\frac{2x}{1.00}$	total of mole fractions = 1
partial pressures	$\frac{0.50-x}{1.00} x P$	$\frac{0.50-x}{1.00} x P$	$\frac{2x}{1.00} x P$	

$$K_p = \frac{(p_C)^2}{(p_A)^2 (p_B)^2} = \frac{\left(\frac{2x}{1.00} x P\right)^2}{\left(\frac{0.50-x}{1.00} x P\right)^2} = 2.55$$

$$\text{Find the square root of both sides: } \frac{\left(\frac{2x}{1.00} x P\right)}{\left(\frac{0.50-x}{1.00} x P\right)} = 1.60$$

$$\frac{2x}{0.5-x} = 1.60$$

$$2x = 1.60(0.5 - x)$$

$$2x = 0.8 - 1.6x$$

$$3.6x = 0.8$$

$$x = 0.222$$