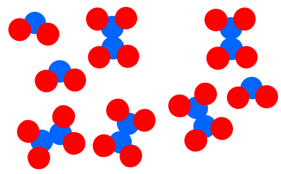
STARTER FOR 10...

2.4. The equilibrium constant, K_p

For gases it is easier to measure the pressure of a gas instead of its concentration. Therefore for equilibria involving only gases we quote the equilibrium constant in terms of pressure and give it the symbol K_p.

1. Complete the table below by calculating the equilibrium composition, the mole fractions, the total pressure or the partial pressures for the equilibria shown. (4 marks)

Equilibrium	$2\ H_2(g) + O_2(g) \rightleftharpoons 2\ H_2O(g)$	$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$	$PCl_5 \rightleftharpoons PCl_3 + Cl_2$
Composition of equilibrium mixture	1 mol H_2 5 mol O_2 4 mol H_2O		………… % PCl_5 ………… % PCl_3 ………… % Cl_2
Mole fractions	H_2 = 0.1 O_2 = 0.5 H_2O = 0.4	NO_2 = …………… N_2O_4 = ……………	PCl_5 = 0.1 PCl_3 = 0.55 Cl_2 = 0.35
Total pressure	20 kPa	100 atm	………………………………
Partial pressures	H_2 = …………… O_2 = …………… H_2O = ……………	NO_2 = 37.5 atm N_2O_4 = 62.5 atm	PCl_5 = 4,600 Pa PCl_3 = 25,300 Pa Cl_2 = 16,100 Pa
Expression for K_p	K_p =	K_p =	K_p =
Value of K_p	K_p = ………………………………………	K_p = ………………………………	K_p = ………………………………

2. Write an expression for K_p, and calculate its value, assuming that each of the systems described above is at equilibrium. (6 marks)

STARTER FOR 10...

2. Equilibria answers

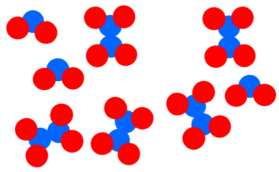
3. Increasing the pressure of the system	no change	2nd floor
4. Increasing the reaction temperature	increases	3rd floor
5. Adding CO to the reaction mixture	no change	3rd floor
6. Decreasing the reaction temperature	decreases	2nd floor
7. Increasing the volume of the reaction container	no change	2nd floor
8. Increasing the amount of H_2 gas in the reaction mixture	no change	2nd floor
9. Increasing the surface area of the catalyst	no change	2nd floor

(9 marks)

Le Châtelier can find his glasses on the 2nd floor …… they were in his office all along! *(1 mark)*

2.4. The equilibrium constant, K_p

1. *4 marks – one for each box fully completed correctly*

Equilibrium	$2\ H_2(g) + O_2(g) \rightleftharpoons 2\ H_2O(g)$	$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$	$PCl_5 \rightleftharpoons PCl_3 + Cl_2$
Composition of equilibrium mixture	1 mol H_2 5 mol O_2 4 mol H_2O		10% PCl_5 55% PCl_3 35% Cl_2
Mole fractions	H_2 = 0.1 O_2 = 0.5 H_2O = 0.4	NO_2 = ⅜ or 0.375 N_2O_4 = ⅝ or 0.625	PCl_5 = 0.1 PCl_3 = 0.55 Cl_2 = 0.35
Total pressure	20 kPa	100 atm	46,000 Pa
Partial pressures	H_2 = 2 kPa O_2 = 10 kPa H_2O = 8 kPa	NO_2 = 37.5 atm N_2O_4 = 62.5 atm	PCl_5 = 4,600 Pa PCl_3 = 25,300 Pa Cl_2 = 16,100 Pa
Expression for K_p	$K_p = \dfrac{(P_{H_2O})^2}{(P_{H_2})^2\,(P_{O_2})}$	$K_p = \dfrac{(P_{N_2O_4})}{(P_{NO_2})^2}$	$K_p = \dfrac{(P_{PCl_3})(P_{Cl_2})}{(P_{PCl_5})}$
Value of K_p	$K_p = 8^2 / (2^2 \times 10)$ K_p = 1.6 kPa^{-1}	$K_p = 62.5 / 37.5^2$ K_p = 0.0444 atm^{-1}	$K_p = \dfrac{(25{,}300 \times 16{,}100)}{4{,}600}$ K_p = 88,550 Pa

(6 marks, 1 for each correct expression for K_p and 1 for each correct value for K_p with correct units)