PART 1 – Equilibrium quantities

1)

	$CH_4(g)$	+ $H_2O(g)$	$\rightleftharpoons$	$CO(g)$	+ $3\,H_2(g)$
initial moles	3.0	2.0		0	0
changes in moles					
equilibrium moles				0.6	

2)

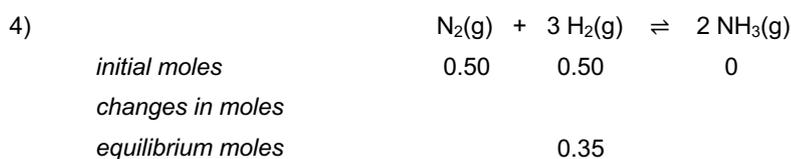|	$CH_4(g)$	+ $H_2O(g)$	$\rightleftharpoons$	$CO(g)$	+ $3\,H_2(g)$
initial moles	0.50	0.20		0	0
changes in moles					
equilibrium moles					0.30

3)

	$N_2(g)$	+ $3\,H_2(g)$	$\rightleftharpoons$	$2\,NH_3(g)$
initial moles	3.0	1.0		0
changes in moles				
equilibrium moles				0.3

4)

	$N_2(g)$	+ $3\,H_2(g)$	$\rightleftharpoons$	$2\,NH_3(g)$
initial moles	0.50	0.50		0
changes in moles				
equilibrium moles		0.35		

5)

	$2A(g)$	+ $B(g)$	$\rightleftharpoons$	$C(g)$	+ $3D(g)$
initial moles	0.40	0.40			
changes in moles					
equilibrium moles					0.30

6)

	$2A(g)$	+ $B(g)$	$\rightleftharpoons$	$C(g)$	+ $3D(g)$
initial moles	0.60	0.20			
changes in moles					
equilibrium moles			0.07		

PART 2 – K_p expressions and units

	equilibrium	K_p	units (assume all pressures are in Pa)
1	$N_2(g) + 3 H_2(g) \rightleftharpoons 2 NH_3(g)$		
2	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$		
3	$H_2(g) + I_2(g) \rightleftharpoons 2 HI(g)$		
4	$2 O_3(g) \rightleftharpoons 3 O_2(g)$		
5	$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3 H_2(g)$		
6	$CO(g) + 3 H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$		
7	$2 SO_2(g) + O_2(g) \rightleftharpoons 2 SO_3(g)$		
8	$N_2O_4(g) \rightleftharpoons 2 NO_2(g)$		

PART 3 – Mole fractions and partial pressures

Mole fraction

If you have 10 moles of a mixture of gases, of which 3 moles is O_2, then the mole fraction of O_2 in the mixture is $\frac{3}{10}$ or 0.3 (or even 30%, but it is not usually expressed as a %)

$$\text{mole fraction of gas A in a mixture of gases} = \frac{moles\ of\ gas\ A}{total\ moles\ of\ gas\ in\ the\ mixture}$$

Note that the sum of all the mole fractions in a mixture should add up to 1

Partial pressure

Imagine a mixture of gases with a total pressure of 100 kPa.

If the mole fraction of gas A in that mixture is $\frac{3}{10}$, then that gas makes up 30 kPa (i.e $\frac{3}{10}$) of the total pressure. The contribution that each gas makes to the total pressure is called the partial pressure of that gas; therefore the partial pressure of gas A is 30 kPa.

$$\text{partial pressure of gas A} = \text{mole fraction of gas A} \times \text{total pressure}$$
in a mixture of gases

Note that the sum of all the partial pressures is the total pressure.

1)

	$CH_4(g)$	+	$H_2O(g)$	$\rightleftharpoons$	$CO(g)$	+	$3\,H_2(g)$	total pressure = 255 kPa
initial moles	2.00		2.00		0		0	
changes in moles								
equilibrium moles							3.60	total moles =
mole fraction								sum of mole fractions =
partial pressure								sum of partial pressures =

2)

	$N_2(g)$	+	$3\,H_2(g)$	$\rightleftharpoons$	$2\,NH_3(g)$	total pressure = 45.0 MPa
initial moles	0.800		1.000		0	
changes in moles						
equilibrium moles					0.400	total moles =
mole fraction						sum of mole fractions =
partial pressure						sum of partial pressures =

3)

	$2\,SO_2(g)$	+	$O_2(g)$	$\rightleftharpoons$	$2\,SO_3(g)$	total pressure = 2.0 MPa
initial moles	5.00		4.00		0	
changes in moles						
equilibrium moles					1.50	total moles =
mole fraction						sum of mole fractions =
partial pressure						sum of partial pressures =

4)

	$H_2(g)$	+	$I_2(g)$	$\rightleftharpoons$	$2\,HI(g)$	total pressure = P
initial moles	1.50		1.00		0	
changes in moles						
equilibrium moles					1.60	total moles =
mole fraction						sum of mole fractions =
partial pressure						sum of partial pressures =

PART 4 – K_p problems

Example: Gases A, B and C are in equilibrium. $2 A(g) + B(g) \rightleftharpoons 2 C(g)$

a) At equilibrium, there are 2.0 moles of A, 2.5 moles of B and 1.5 moles of C. The total pressure is 500 kPa. Calculate the value of K_p

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b) If the total pressure of this equilibrium was increased, explain what would happen to the yield of C and the value of K_p

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c) The forward reaction is exothermic. If the temperature of this equilibrium was increased, explain what would happen to the yield of C and the value of K_p

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