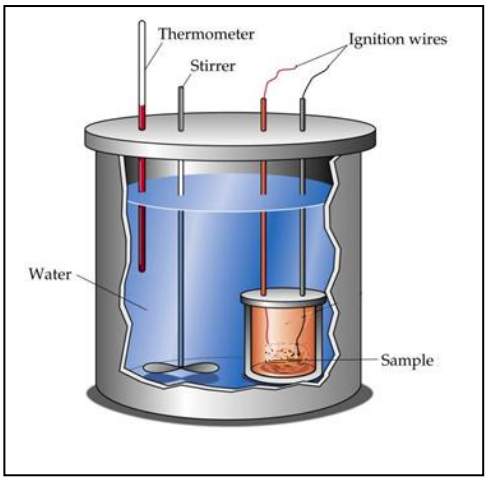
Friday Worksheet **Name: …….**

Ammonia production worksheet 3

1) Hydrogen and nitrogen gases were mixed in a bomb calorimeter and allowed to react according to the equation below.



$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ ΔH = -ve

The combustion chamber of the bomb calorimeter has a volume of 1.50 litres. A mixture of hydrogen and nitrogen containing 2.13 mol of H_2 gas and 3.20 mol of N_2 gas was placed in the chamber, ignited and allowed to reach equilibrium. At equilibrium it was found that 3.41 grams of ammonia was present in the chamber.

a) Calculate the number of mol of each species at equilibrium
Step 1 find the mol of ammonia.
=> 3.41/17.0 = 0.201
Step 2 find the mol of N_2
=> 3.20 – 0.100 = 3.10
Step 3 find the mol of H_2
=> 2.13 – 0.300 = 1.83

b) Calculate the equilibrium constant at the temperature at which the measurements were taken.
$[NH_3]^2 / [N_2][H_2]^3 = K_c$
Step 1 find the concentrations of all species present
=> $[NH_3] = 0.201 / 1.50 = 0.134M$
=> $[H_2] = 1.83 / 1.50 = 1.22M$
=> $[N_2] = 3.10 / 1.50 = 2.07M$
Step 2 calculate K_c
$[NH_3]^2 / [N_2][H_2]^3 = K_c = [0.134]^2 / [2.07][1.22]^3 = 4.78 \times 10^{-3} M^{-2}$

c) A mixture of gases was placed in the same reaction chamber at exactly the same temperature. The mixture of 0.100 mol of N_2, 0.100 mol of H_2 and 0.100 mol of NH_3 was allowed to reach equilibrium. Which comment below is true? Explain.
a) When the system reaches equilibrium the final concentration of ammonia will be lower than the initial concentration.
b) When the system reaches equilibrium the final concentration of hydrogen will be greater than the initial concentration.
c) When the system reaches equilibrium the final concentration of ammonia will be half that of the initial concentration
d) When the system reaches equilibrium the final concentration of nitrogen will be the same as the initial concentration
Calculate the value of the K expression.
Step 1 find the concentrations of all species present
=> $[NH_3] = 0.100 / 1.50 = 0.0667M$
=> $[H_2] = 0.100 / 1.50 = 0.0667M$

=> $[N_2]$ = 0.100 / 1.50 = 0.0667M1

$[NH_3]^2 / [N_2][H_2]^3 = K_c = 0.0667^2 / (0.0667 \times 0.0667^3) = 225\ M^{-2}$

Since the temperature has not changed the equilibrium expression should be the same value as in b) above.

Since225 M^{-2} is clearly too high the system will move to increase the amount of H_2 and N_2 and lower the amount of NH_3.

Hence a) is true.

d) In another experiment 1.00 mol of N_2 was mixed with 1.00 mol of H_2 and ignited in a 0.500 litre, sealed container. After the system had reached equilibrium it was found that 0.400 mol of NH_3 was present. Calculate the pressure, atm, exerted by the equilibrium mixture of gases at 20.0 ^oC to the right number of significant numbers

Step 1 find the mol of each gas present using the stoichiometry of the equation

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

=> NH_3 = 0.400

=> N_2 =(1.00 – 0.200) = 0.800

=> H_2 = (1.00 – 0.600) = 0.400

Step 2 total number of mol of gas

=> 0.400 + 0.400 + 0.800 = 1.600

Step 3 find the pressure in KPa

P =nRT/V = 0.1600 X 8.31 X 293 / 0.500 = 7791 kPa

Step 4 convert to atm

7791/101.3 = 76.9

2) A fertiliser company produces ammonia on a large scale at a temperature of 450^0 C. Adjustments were made to the conditions of an equilibrium mixture of nitrogen, hydrogen and ammonia gases in order to increase the yield of ammonia.

In a trial run on a small scale in the laboratory, an engineer makes adjustments to the conditions of the equilibrium mixture. The graph below represent the results obtained.

a) What happened at t_2?

Volume of the reaction chamber was halved.

b) What happened at t_3?

Temperature of the reaction chamber was decreased.

c) The value of the equilibrium expression is represented by K_c.

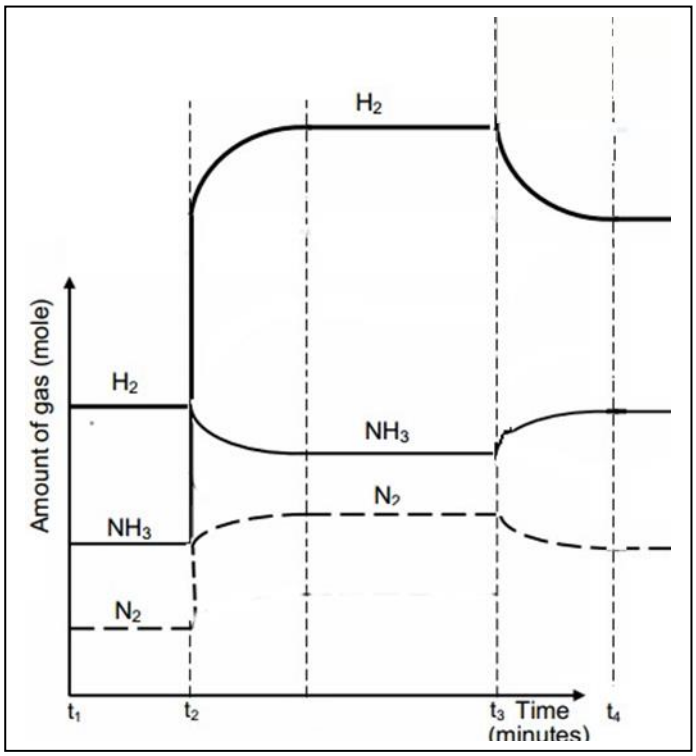
Compare the

- K_c at t_1 to the K_c at t_2? Explain

No change as there is no temperature change.

- K_c at t_1 to the K_c at t_4? Explain

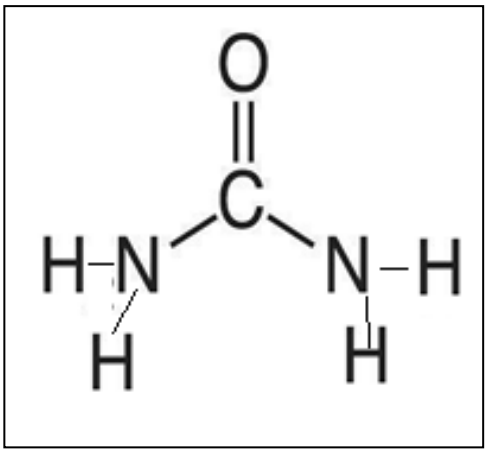
Reaction system drives backward thus lowering the value of the equilibrium expression.



3) Amino acids are degraded in the liver via a reaction that produces ammonia. The amine group of the amino acid is converted to. This process is called **deamination**. The non-nitrogenous portion of the molecule is converted to carbohydrates or fats. The overall equation for deamination of an amino acid in the liver is:
$2NH_2CHRCOOH + O_2 \rightarrow 2CROCOOH + 2NH_3$

Ammonia is highly toxic and therefore cannot be allowed to accumulate. With the help of enzymes in the liver cells carbon dioxide reacts chemically with the ammonia molecule. The less toxic nitrogenous compound urea is produced together with water according to the equation below.

$CO_2 + 2NH_3 \rightarrow (NH_2)_2CO + H_2O$
Draw the structural formula of urea.



Explain why urea is soluble in water.

Both water and urea have hydrogen bonding as the intermolecular forces acting to hold molecules together. Hence both molecules interact with each other.