Assessment task

Equilibrium Revision

61

Question 1

Consider the reaction,

$$3H_{2(g)} + N_{2(g)} \leftrightarrows 2NH_{3(g)} \quad \Delta H = -91 \text{ kJ/mol}$$

A mixture of hydrogen gas and nitrogen gas is placed in a reaction chamber and allowed to reach equilibrium. A number of events take place to disrupt the equilibrium. Compare the changes that occur between the initial equilibrium position and the final equilibrium position.

Complete the table below by circling the correct response

Action on the equilibrium	***Equilibrium constant*** Circle one of the options below	***Mol H_2*** when equilibrium is established	***Mol N_2*** when equilibrium is established	***Mol NH_3*** when equilibrium is established
Addition of NH_3	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change
The reaction chamber is doubled in volume	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change
The reaction vessel is heated	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change
The reaction vessel is cooled	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change
Addition of H_2	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change	Increase Decrease No change

20 marks

20

Question 2

The cells in the body produce carbon dioxide as a product of respiration. The equilibrium, between gaseous carbon dioxide and dissolved carbon dioxide, is established.

$$CO_2(g) \leftrightarrows CO_2(aq)$$

Carbon dioxide dissolves in water to form the weak acid known as carbonic acid.

$$CO_2(aq) + H_2O(l) \leftrightarrows H_2CO_3(aq)$$

Carbonic acid is in equilibrium with the hydrogen carbonate ion as shown below.

$$H_2CO_3(aq) + H_2O(l) \leftrightarrows HCO_3^-(aq) + H_3O^+(aq)$$

Air taken into the lungs has a very low concentration of carbon dioxide.

a) What effect will hyperventilating (rapid breathing) have on the blood pH?

1 mark

b) Use Le Chatelier's Principle to explain the changes in blood pH as blood travels from the tissues to the lungs.

2 mark

c) During a heart attack, blood stops circulating but the cells in the body continue to respire producing carbon dioxide. Before the heart is restarted doctors often inject a solution of sodium hydrogen carbonate($NaHCO_3$) directly into the heart. Use Le Chatelier's Principle to explain why.

2 mark

d) Use Le Chatelier's Principle to explain how blood pH will change if a person enters a room filled with carbon dioxide gas.

2 mark

7

The reaction equation for the Haber process is given below.

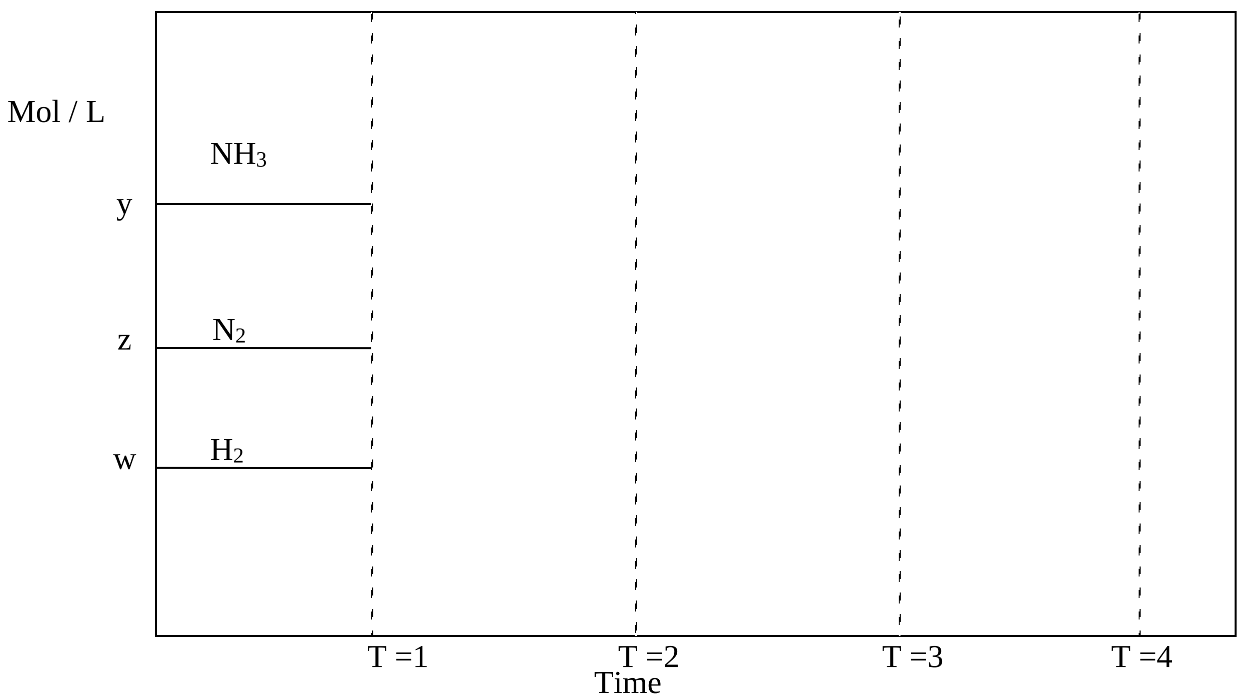
$$N_2(g) + 3H_2(g) \leftrightarrows 2NH_3(g) \quad \Delta H = -91 \text{ kJ/mol}$$

Question 3

2.80 grams of nitrogen gas reacts with 0.600 grams of hydrogen gas in a sealed 2.00 litre reaction vessel. After sometime equilibrium is reached at which point the amount of ammonia was found to be 0.170 grams.

(a) Calculate the equilibrium constant for the above reaction at the specified temperature.

3 marks



(b) On the set of axis above sketch the concentration changes of the system when at :

i) T=1 helium gas is added to the system to increase the pressure and equilibrium is achieved before T=2.

ii) T =2 the reaction vessel is cooled and equilibrium is achieved before T=3.

iii) T =3 the volume o the reaction vessel is halved and equilibrium is achieved before T=4.

iv) T =4 hydrogen gas is injected into the reaction vessel.

4 marks

7

Question 4

The reaction equation below describes the equilibrium that exists between the Fe^{3+}(aq) cation, the SCN^{1-}(aq) anion, and the complex ion $Fe(SCN)^{2+}$(aq).

$$Fe^{3+}(aq) + SCN^{1-}(aq) \leftrightarrows Fe(SCN)^{2+}(aq)$$

The Fe^{3+}(aq) is a pale yellow colour and complex the $Fe(SCN)^{2+}$(aq) ion is a red colour.

To a pale yellow solution of the Fe^{3+}(aq) ions:

Action on the equilibrium	***Expected colour change*** ***Circle the appropriate response***
potassium thiocyanate (KSCN) solution is slowly added	The solution turns from reddish to deeper red The solution turns from pale yellow to reddish The solution turns from reddish to a pale yellow The colour of the solution remains unchanged
To the resulting solution iron(III)nitrate is added.	The solution turns a deeper red The solution turns from pale yellow to reddish The solution turns from reddish to a pale yellow The colour of the solution remains unchanged
The resulting solution is now left overnight so that water evaporates and the volume of the original solution is halved.	The solution turns a deeper red The solution turns from pale yellow to reddish The solution turns from reddish to a pale yellow The colour of the solution remains unchanged
A catalyst is added to the solution above.	The solution turns from reddish to deeper red The solution turns from pale yellow to reddish The solution turns from reddish to a pale yellow The colour of the solution remains unchanged

4 marks

Question 5

Consider the following systems in the table below. If each system is at equilibrium predict what effect the stated action will have on *K* and the mol of reactants present when the system is allowed to reach equilibrium once more.
Circle the appropriate response in the table below.

Equilibrium system	***Action***	***Change in K***	***Change in the mol of reactants***
$H_{2(g)} + I_{2(g)} \Rightarrow 2HI_{(g)}$	Volume is doubled	Increase Decrease Unchanged	Increase Decrease Unchanged
$H_{2(g)} + I_{2(g)} \Rightarrow 2HI_{(g)}$	Helium gas is added at constant volume	Increase Decrease Unchanged	Increase Decrease Unchanged
$2C_4H_{10(g)} + 13O_{2(g)} \Rightarrow 8CO_{2(g)} + 10H_2O_{(l)}$ $\Delta H = -91$ kJ/mol	The reaction vessel is heated	Increase Decrease Unchanged	Increase Decrease Unchanged
$2SO_{2(g)} + O_{2(g)} \Rightarrow 2SO_{3(g)}$	Volume is doubled	Increase Decrease Unchanged	Increase Decrease Unchanged
$CH_{4(g)} + 2O_{2(g)} \Rightarrow CO_{2(g)} + H_2O_{(g)}$ $-\Delta H$ kJ/mol	The reaction chamber is cooled.	Increase Decrease Unchanged	Increase Decrease Unchanged

10 marks

10

Question 6

Nitrogen gas and hydrogen gas react in a 2 L sealed vessel according to the following equation.

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

The system is allowed to reach equilibrium and the equilibrium constant calculated at 4.00 M^{-2}. Analysis shows that twice as many mol of hydrogen are present than mol of nitrogen. While the same number of mol of ammonia and hydrogen gas exist.
Calculate the mass of nitrogen, hydrogen and ammonia at equilibrium.
Atomic mass N =14.0, H = 1.01

6 marks

Question 7

Phosgene gas is a known toxin used in chemical warfare, It is produced according to the equation below.

$$CO(g) + Cl_2(g) \leftrightharpoons COCl_2(g) \ \Delta H = ?kJ/mol.$$

This gas ($COCl_2$) quickly decomposes when strongly heated to CO and Cl_2 gases.

a) According to the information given suggest whether the synthesis of phosgene is an exothermic or endothermic reaction. Give reasons.

1 mark

b) At a given temperature of 100°C the reaction below has an equilibrium constant, K_c = 2.20 X 10^{-10} M.
$COCl_2(g) \leftrightharpoons CO(g) + Cl_2(g)$
If 0.100 mol of phosgene, $COCl_2$, is placed in a 1.00 L sealed vessel, calculate the concentration of carbon monoxide at equilibrium.

3 marks

c) What can you say about the amount of phosgene gas produced at 100°C. Explain

1 mark

Question 8

When carbon monoxide binds to hemoglobin it forms bonds that are, roughly, 300 times stronger than the bonds formed between hemoglobin and oxygen. As a consequence the equilibrium constant for the formation of carboxyhemoglobin, according to the equation Hb *(aq)* + 4CO *(g)* ⇋ $Hb(CO)_4$ *(aq)* is much higher than for the hemoglobin-oxygen reaction Hb *(aq)* + $4O_2$ *(g)* ⇋ $Hb(O_2)_4$ *(aq).* Hemoglobin that is bound to carbon monoxide is no longer available to bind oxygen and this can cause asphyxiation in organisms. Treatment of carbon monoxide poisoning involves the use of a hyperbaric chamber to drive the reaction below.
$Hb(CO)_4$ *(aq)* + $4O_2$ *(g)* ⇋ $Hb(O_2)_4$ *(aq)* + 4CO *(g).*

Explain, using ***Le Chatelier's***, how hyperbaric chamber can treat carbon monoxide poisoning.

2 marks

2