1 Worksheet: Chemical equilibrium

QUESTION 1

1.1 A mixture of 2 mol CO(g) and 2 mol H_2(g) is sealed in a container. Equilibrium with metanol (CH_3OH) is established according to the following equation:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Which ONE of the following statements is CORRECT?
At equilibrium the mixture will contain . . .

A 3 mol CH_3OH.
B 2 mol CH_3OH.
C 1 mol CH_3OH.
D less than 1 mol CH_3OH.

1.2 Write equations for the equilibrium constant for each of the following reactions:

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(l)$	
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$	

1.3 PCl_5 decomposes according to the following equation:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

At equilibrium $[PCl_5]$ = 0,10 mol.dm^{-3}, $[PCl_3]$ = 0,15 mol.dm^{-3} and $[Cl_2]$ = 0,37 mol.dm^{-3}. Calculate the equilibrium constant.

1.4 $ZnO(s) + CO(g) \rightleftharpoons Zn(s) + CO_2(g)$. At 400 K the K_c-value for this reaction is 2,78. If there is 5,6 g CO(g) in the 3 dm^3 container at equilibrium, calculate the concentration of the CO_2.

1.5 3,70 mol of A is placed in a 4 dm^3 container and heated. When equilibrium is established at 700°C 38,8% of A has dissociated according to the equation:
$3A(g) \rightleftharpoons 5B(g) + 2C(g)$. Calculate the equilibrium constant at this temperature.

1.6 At 400 K the equilibrium constant for the reaction $Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$ is 7,00. 48 g Br_2 and 21,3 g Cl_2 are sealed in a 2 dm^3 container. What is the concentration of BrCl at equilibrium?

QUESTION 2

2.1 Chromate ions and dichromate ions are in equilibrium with each other in an aqueous solution according to the following balanced equation:

$$\underbrace{2CrO_4^{2-}(aq)}_{\text{yellow}} + 2H^+(aq) \rightleftharpoons \underbrace{Cr_2O_7^{2-}(aq)}_{\text{orange}} + H_2O(\ell)$$

Which ONE of the following reagents should be added to change the colour of the solution to more yellow?

A HNO_3
B H_2O
C LiOH
D K_2CrO_4

2.2 Consider the following reaction that reaches equilibrium in a closed container:

$$C(s)+CO_2(g) \rightleftharpoons 2CO(g) \quad \Delta H > 0$$

How will the amount of CO(g) change if the following takes place?

a. Temperature is decreased.
b. The volume of the container is increased at constant temperature.
c. More carbon is added.
d. A catalyst is added to the container.

2.3

Consider the following reaction:

$$\underbrace{Cu(H_2O)_6^{2+}(aq)}_{\text{blue}} + 4Cl^-(aq) \rightleftharpoons \underbrace{CuCl_4^{2-}(aq)}_{\text{green}} + 6H_2O(\ell) \quad \Delta H > 0$$

What will happen to the colour of the solution when ...
(Write only more blue, more green or stays constant)

a	the solution is cooled	
b	concentrated HCl is added	
c	a few drops silver nitrate is added	
d	a few drops of water is added	
e	a few NaCl crystals are added	

2.4 Consider the following reaction that reaches equilibrium in a closed container:

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g) \quad \Delta H > 0$$

How will the amount of $NH_3(g)$ change if the following takes place?

a. The pressure is increased by decreasing the volume of the container.
b. More $H_2S(g)$ is added.
c. More $NH_4HS(s)$ is added.
d. Temperature is increased.

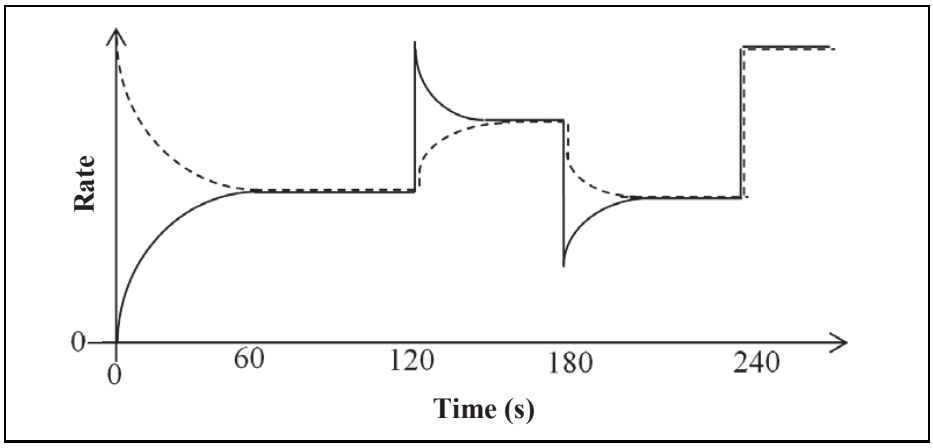
QUESTION 4

(Question 3 focuses on the study material covered in video 3 and 4.)

Ammonia is introduced into a flask, which is then sealed and allowed to reach dynamic chemical equilibrium at a certain temperature. The balanced chemical equation for the reaction is:

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

The graph below shows the changes in the rates of the forward and reverse reactions with time. The dotted line represents the forward reaction.



4.1 Write down the reaction that is represented by the solid line. (1)

4.2 Explain why the rate of the reverse reaction increases (as shown on the graph) during the first 60 s. (2)

4.3 At t = 120 s the volume of the container is changed at constant temperature.

a. Is the volume increased or decreased? Explain the answer. (2)

b. The graph shows that at t = 120 s, the rates of BOTH the forward and reverse reactions increase immediately. Why is this so? (2)

c. Which reaction is favoured between t = 120 s and t = 150 s (FORWARD OR REVERSE)? (1)

d. Explain your answer to question c by applying Le Chatelier's Principle. (2)

e. How does the K_c value at 150 s compare with the K_c at 100 s? (1)

4.4 At t = 180 s the temperature is changed and pressure is kept constant.

a. Is the temperature increased or decreased? Explain the answer. (2)

b. Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Explain by applying Le Chatelier's Principle. (3)

c. How does the K_c value at 200 s compare with the K_c at 150 s? (1)

4.5 Name a change in reaction conditions that can explain the graph at t = 240 s. (1)

4.6 How does the concentration of $H_2(g)$ change between 230 s and 250 s? Explain. (3)

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