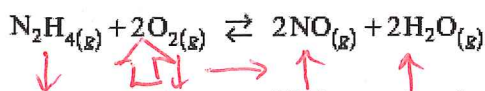


Assignment 2 – Equilibrium (Theory)

1. a) Why are chemical equilibria referred to as dynamic? (1 mark)
Both forward and reverse reactions continue to occur.
- b) How is a chemical system at equilibrium recognized? (1 mark)
Constant macroscopic properties.

2. Consider the following equilibrium:

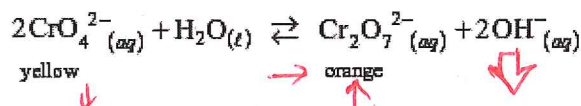


More oxygen is added to the above equilibrium. After the system re-establishes equilibrium, identify the substance(s), if any, that have a net (2 marks)

a) increase in concentration. *O₂, NO, H₂O*

b) decrease in concentration.
N₂H₄

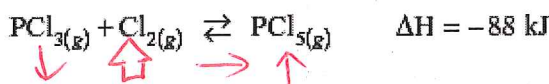
3. Consider the following equilibrium:



When HCl is added drop-by-drop to the yellow solution above, the solution turns orange. Explain why this colour change occurs. (2 marks)

If neutralize the OH⁻, [OH⁻] decreases so the equilibrium shifts to the right to make more Cr₂O₇²⁻. This causes the solution to turn orange.

4. Consider the following equilibrium:



What happens to the [PCl₃] when additional Cl₂ is added at constant temperature and volume? Explain. (2 marks)

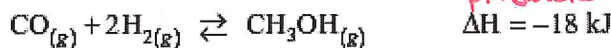
[PCl₃] decreases as the equilibrium shifts to the right to use up

5. Identify four characteristics of a chemical equilibrium. (2 marks)

- closed system
- constant T
- constant macroscopic properties

- reversible
 - forward rate = reverse rate
 - both reactants/products are present
- the additional Cl₂.*

6. Consider the following equilibrium:



Explain, using Le Chatelier's principle, how the following changes will affect the number of moles of CH₃OH present at equilibrium.

a) Adding a catalyst. *No shift & no change* (1 mark)

b) Decreasing the volume of the system. *equilibrium shifts to the right (lower # of mols) so the moles of CH₃OH will increase.* (1 mark)

Assignment 2 – Equilibrium (Theory)

7. Consider the following equilibrium:



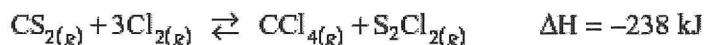
What happens to the amount of Cl_2 when the following changes are imposed?
Explain, using Le Chatelier's principle.

a) Removing $\text{NO}_{(g)}$ shifts to the left \therefore amt. of $\text{Cl}_2 \uparrow$ (1 mark)

b) Decreasing the temperature. (1 mark)

shifts in the exothermic direction (right)
 \therefore amt of Cl_2 will decrease.

8. Consider the following equilibrium:



Some CS_2 is added and equilibrium is then reestablished. State the direction of the equilibrium shift and the resulting change in $[\text{Cl}_2]$. (1 mark)

shifts to the right to remove the CS_2 .
 $\therefore [\text{Cl}_2]$ will decrease.

9. State Le Chatelier's Principle. When a system at equilibrium (2 marks)
is subjected to a stress, the system shifts to counteract the stress and re-establish an equilibrium.
10. Describe how enthalpy and entropy change, in the forward direction, as an exothermic reaction reaches equilibrium. Explain your reasoning. (2 marks)

Enthalpy: is decreasing

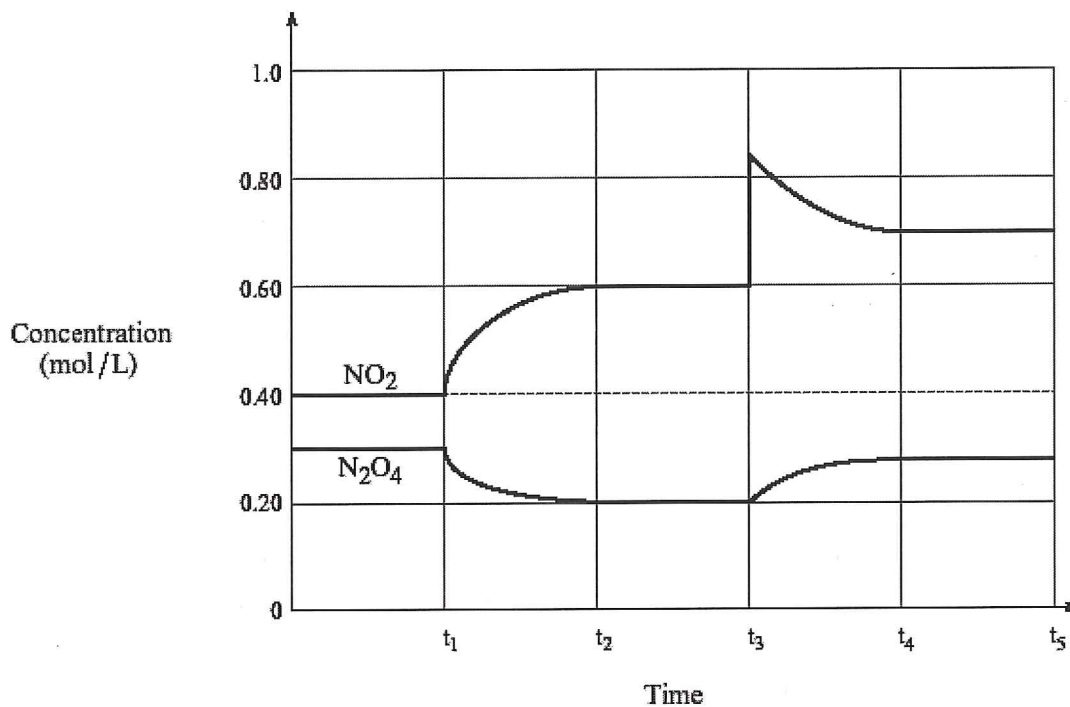
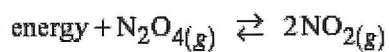
Entropy: is decreasing as the enthalpy is favoring the forward reaction entropy must be favoring the opposite direction.

Enthalpy

As the system is going to minimum enthalpy the max entropy must be opposing that force to create the equilibrium

Assignment 2 – Equilibrium (Theory)

11. Consider the following graph for the reaction:



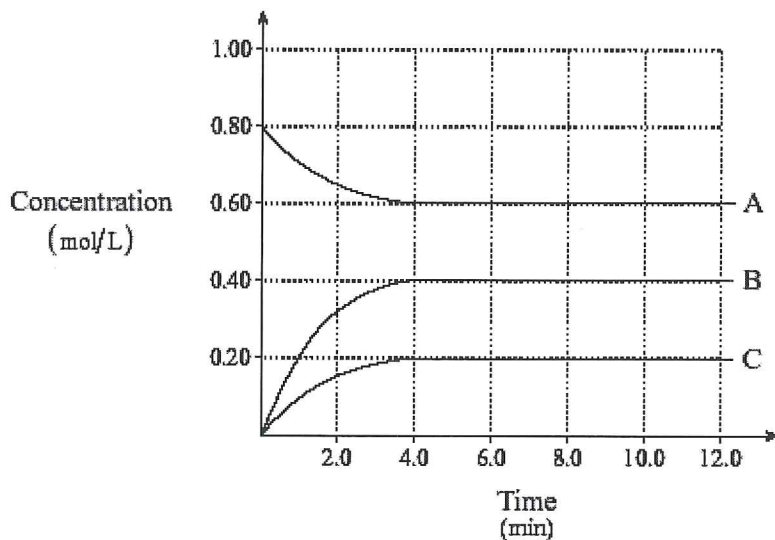
- a) What is the stress imposed at time t_1 ? T ↑ (1 mark)
- b) What is the stress imposed at time t_3 ? NO₂ was added. (1 mark)
- c) Calculate K_{eq} for the equilibrium between t_2 and t_3 . (2 marks)

$$K_{eq} = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.60\text{M})^2}{(0.20\text{M})} = 1.8$$

* The equilibrium is attained at t_4

Assignment 2 – Equilibrium (Theory)

12. Consider the following diagram for a chemical system containing three substances represented by A, B and C:



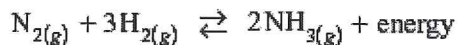
- a) What feature of the graph indicates that the system reaches equilibrium? (1 mark)

The concentration becomes constant.

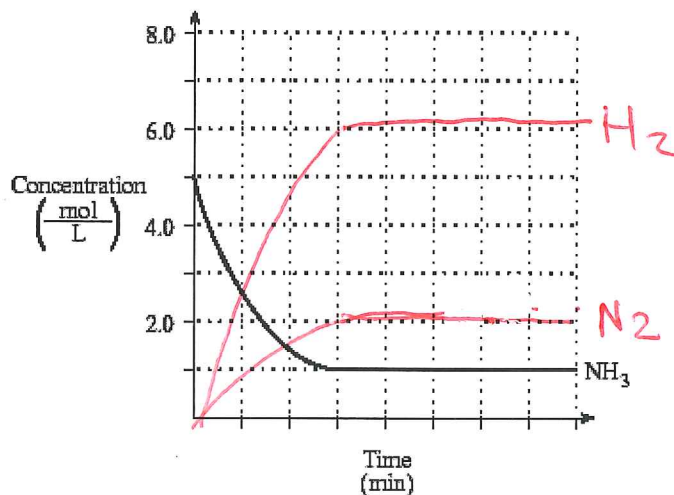
- b) Write a balanced equation for the equilibrium reaction. (2 marks)



13. Consider the following equilibrium system:



A 1.00 L container is filled with 5.0 mol NH_3 and the system proceeds to equilibrium as indicated by the graph.



Draw and label the graph for N_2 and H_2 .

(2 marks)