Topic 8 –Equilibria
Revision Notes

1) Dynamic Equilibrium

- In a closed system, a reversible reaction will reach a state of dynamic equilibrium. A dynamic equilibrium has the following characteristics
- Forward rate = backward rate
- Concentrations are constant

2) Le Chatelier's Principle

- Le Chatelier's Principle predicts how a system in dynamic equilibrium will respond to a change. The Principle states that: "An equilibrium opposes change"
- The position of equilibrium (composition of the mixture of reactants and products) will shift to the left or right if a change is made to concentration, temperature or pressure
- Both examples mentioned in the specification are exothermic in the forward direction and have fewer gaseous moles on the right

Example 1 $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\mathbb{N}H = -90$ kJ mol^{-1}

Example 2 $H_2C{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$ $\mathbb{N}H = -45$ kJ mol^{-1}

a) Effect of changing concentration

- If reactants are added, the equilibrium will shift to the right to remove the added reactants
- If products are removed, the equilibrium will shift to the right to replace the products that have been removed

b) Effect of changing temperature

- If the temperature is increased, the equilibrium will shift in the endothermic direction to remove the added heat (to the left in this case)
- If the temperature is decreased, the equilibrium will shift in the exothermic direction as this replaces the heat that has been removed (to the right in this case)
- In the above examples, the highest yield of products is obtained with a low temperature because the forward reactions are exothermic

c) Effect of changing pressure

- In the above reactions there are more moles of gas on the left than on the right. The products have a smaller volume than the reactants
- If the pressure is increased, the equilibrium will shift to side with the fewer gaseous moles as this reduces the pressure and opposes the change (to the right in this case). This gives the highest yield of products
- If the pressure is decreased, the equilibrium will shift to the side with more gaseous moles as increases the pressure and opposes the change (to the left in this case). This would decrease yield in the above reactions

d) Effect of adding a catalyst

- Adding a catalyst has no effect on the position of equilibrium
- A catalyst speeds up the rates of the forward and backward reactions equally
- Its effect is to reduce the time taken to reach equilibrium
- Both of the above processes use catalysts to speed up the reactions

e) Compromise conditions

- In practice low temperatures are not used as the reaction rate would be too low. Compromise temperatures of 250-300 C give a reasonable yield at a reasonable rate
- In addition, a very high pressure is not used as it is requires expensive equipment. Compromise pressures of 50-100 atm give a reasonable yield at a reasonable equipment cost
- Finally, unreacted starting materials are recycled to the reaction vessel

f) Use of products

- Both methanol and ethanol are important as liquid fuels
- Both have high octane ratings and can be added to petrol