**INDUSTRIAL AND ENGINEERING CHEMISTRY ASSIGNMENT**

**(13CHE1057)**

**1. Equilibrium conversion of SO2 to SO3**

SO2 + 1/2O2 => SO3

Let the inlet feed be of 100 moles

Therefore inlet composition as give:

SO3 = 0 moles

SO2 = 8 moles

O2 = 12 moles

N2 = 80 moles

Total moles = 100 moles

Let ‘Ɛ’ be the conversion of SO2

Therefor the outlet composition from reactor

SO3 = Ɛ moles

SO2 = 8- Ɛ moles

O2 = 12- Ɛ/2 moles

N2 = 80 moles

Total moles = 100- Ɛ/2

We know,

ΔG = -RTlnK

ΔG = ΔGf of SO3 – ΔGf of SO2

K=exp(-ΔG/RT)

K = [(Ɛ)(100- Ɛ/2)^0.5]/[(8- Ɛ)(12- Ɛ/2)^0.5]

Thus we get an expression for Ɛ and T

exp(-ΔG/RT)= [(Ɛ)(100- Ɛ/2)^0.5]/[(8- Ɛ)(12- Ɛ/2)^0.5]

Following is the data obtained:

ΔG(Kcal/mole) formation of SO3:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| -22.74 | -10.512 | -10.428 | -5.65 | -0.78 | 4.15 | 9.11 | 14.1 |

Percent Conversion:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 100 | 99.99999324 | 99.99999132 | 99.71864114 | 41.56389532 | 0.108042818 | 0.054690051 | 0.019868119 |

Temperatures (K):

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 298.16 | 300 | 400 | 500 | 600 | 700 | 800 |

Graph of %Conversion vs Temperature (K):

**2. Effect of pressure on SO2 to SO3 conversion**

In the forward reaction i.e. formation of sulphur trioxide, the number of moles of gaseous components is decreasing. The formation of SO3 takes place with decrease in volume and hence increase in pressure is expected to increase the rate of formation of SO3, i.e., rate of forward reaction. However, it has been observed that there is no appreciable change in the yield at higher pressures. Also, higher pressure will increase the rate of corrosion of iron tower used in the process. Hence pressure of 1.5-1.7 atm is usually satisfactory.

**3. Use of S02 in distilleries**

Sulphur is often used in sugar cane processing. Sulphur dioxide can be used for a variety of reasons during the processing of sugar cane or the production of molasses. Most commonly, sulphur dioxide is used to lighten the colour of the molasses or to help extend its shelf life. It may also be used to help with the processing of sugar cane when the cane has been harvested at an early stage.

**4. Turnover frequencies**

At 200 degree Celsius Isopropanol oxidation turnover frequencies are:

|  |  |  |
| --- | --- | --- |
|  | Turnover frequencies(s-1) | |
|  | Redox | Acidic |
| V2O5 | 0.018 | 18 |
| PtO | 110 | - |

**5. Challenge in increasing TOF**

The turnover frequency of cyclohexene to cyclohexane was shown to increase with smaller Rh particle size. The challenge involved in application of small catalyst particles is maintaining surface area and to keep agglomeration at a minimum.

**6. Other oxidation reactions catalysed by V2O5**

1. Oxidation of methanol to formaldehyde
2. The selective oxidation of propylene to acrolein
3. The oxidation of 2-butanone over V2O5 in the presence of steam producing acetic acid and acetaldehyde quite selectively with 2,3-butanedione and carbon oxides as other major products.
4. Selective oxidation of H2S to sulphur from biogas on V2O5/CeO2 catalysts.

**7. Enhancement in reaction rate without the use of catalysts**

Liquid solid non- catalytic reactions are one class of heterogeneous reactions. Microphase, microemulsions and ultrasound are some of the methods which can be used to achieve enhancement in conversions for such reactions. In general a reaction to take place the reacting molecules have to come in contact with each other. So when the reagents are present in two phases which are immiscible, then reaction is not at all possible or if at all reaction takes place the reaction is very slow. So for such heterogeneous reactions the use of micro phase will enhance the conversions. . Ultrasound has been shown to have desirable effects on both homogeneous and heterogeneous reactions such as increasing the conversion enhancing the selectivity and improving the yield. The enhancements are attributed to chemical effects and mechanical effects. Microemulsions: induces the super saturation of a sparingly soluble solid in a liquid system.

The micro phase particles are not true catalysts but enhance rates by strongly adsorbing the organic phase reactant (which is otherwise sparingly soluble in the aqueous phase) and provide for increased contact for reaction between the organic and aqueous phase reactants in the aqueous film.

As the size of the solid particle reduces the conversion rates are higher and similarly as the concentration of liquid is increased the conversion rates increase.

**8. Cost of a sulphuric acid plant**

Solution:

In 2013

Size = 1000TPD

Cost Index = 567.3

In 1971

Size = 500TPD

Cost Index = 130

Cost= 53.5 million

Using the relation,

C = [a x S] n

Where, ‘ C ’ is the cost in Rupees

‘ S ’ is the size of the plant in TPD

‘ a ’ is a constant.

‘ n ’ is the Exponential Factor (assume 0.65)

Therefore,

In 1971

53.5 = [a x 500] x 0.65

a = 0.1646

In 2013

Cost = [0.1646 x 1000] x 0.65

=107 million

i.e. Original cost =107 million

Therefore the cost of plant in 2013

= (Original Cost) x (Present Cost Index) / (Past Cost Index)

=107 x 567.3/130

=466.93 million

Thus we conclude that the above computed figure is very less as compared to the quoted figure of 1500 million