Q What is atom economy?
How % atom economy is calculated?

Ans → Atom economy → Atom economy of a reaction indicates that out of total mass of reactants used in a reaction, how much % of it is converted into our desired product and how much % of it has wasted.

$$\% \text{ atom economy} = \frac{\text{Molar mass of desired Product}}{\text{Molar mass of all reatants}} \times 100.$$

$$\text{Atom economy} = \frac{\text{mass of desired product}}{\text{mass of all reactants}} \times 100$$

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Higher the value of atom economy, more efficient is a reaction and vice versa.
also we can say that higher the value of atom economy less waste by product has been formed
Therefore, the aim of green chemistry is to always design such a process which has a high value of atom economy.

Q Calculate the atom economy of given reaction

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$$

For reactants

Ans → Molar mass of Fe = $2 \times 55.85 = 111.7$

" " " O = $6 \times 16.00 = 96.0$

" " " C = $3 \times 12.01 = 36.03$

Total molar masses of reactants = $111.7 + 96.0 + 36.03$

$= 243.7$

For Products → (Desired Product is Fe)

molar mass of Fe = $2 \times 55.85 = 111.7$

Now, % atom economy $= \dfrac{\text{molar mass of desired product}}{\text{molar masses of all the reactants}} \times 100$

$= \dfrac{111.7}{243.7} \times 100$

$= 46\%$ (approx.)

ie Here 54% of mass of reactants has wasted.

Q Calculate the atom economy for the manufacture of H_2 by reacting methane with steam

Ans →

$$CH_4(g) + \underset{\text{steam}}{H_2O(g)} \longrightarrow 3H_2(g) + CO(g)$$

For reactants →

Molar mass of C = 12.01

" " O = 16.00

" " H = 6 × 1.0 = 6.0

Total molar mass of reactants = 12.0 + 16.0 + 6.0

= 34.0

For Products (Desired Product is H_2) →

Molar mass of H = 3 × 2.0

= 6.0

Now, % atom economy = $\frac{\text{Molar mass of desired product}}{\text{Molar masses of all the reactants}} \times 100$

= $\frac{6.0}{34.0} \times 100$

= 17.6%

Here, 82.4% mass of reactants has wasted

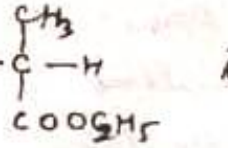
Q What do you understand by green solvent?

Ans → Green solvents are also called as Biosolvents They are environment friendly solvents which are derived from the agricultural crops

Carbohydrate —(i) Fermentation, (ii) Purification→ Lactic Acid —Esterification→ Lactate ester —special method of derivation→ Green solvent

In our daily life commonly used solvents are obtained from petrochemical solvents which are more or less hazardous in nature for the environment

After the Montreal Protocol Green solvents were developed which are alternative to petrochemical solvents are more eco-friendly.

eg Ethyl lactate,  is a green solvent and has been derived from Corn.

This compound is used as solvent in paint industry and is complete biodegradable, easy to recycle, non-corrosive, non-Carcinogenic and does not affect ozone layer.

Ethyl lactate has following unique properties

a) It has solvency power
b) It has high B.P.
c) It has low Vapour Pressure
d) It has low Surface tension
e) It is used as paint stripper and graffiti remover

Ethyl lactate has replaced solvents like toluene, acetone and Xylene. This is also used as cleaner for polyurethane industry, metal surfaces, removing greases, oils, adhesives and solid fuels.

Similar compounds which has been also used are super critical Carbondioxide and ionic liquids

Q How the waste (by-product) can be prevented?

Ans → The waste (by-product) can be prevented by incorporating following facts in our practices

1. Buying resuable items
2. Using compostable items
3. choosing natural items
4. Avoiding disposable items
5. making Eco-friendly items
6. Buying bulk items
7. Appreciating repurposed items
8. Repairing old items
9. Investing in high quality items
10. Buying second hand items
11. Donation of unwanted items
12. Rethinking recycling items
13. Recycling electrical items
14. Utilizing digital items
15. Knowing our stuff.

Q Write note on Ionic liquids.

Ans → Ionic liquids are highly solvating, non-coordinating medium in which a variety of organic and inorganic solute dissolve. Due to lack of measurable vapour pressure, it is a good substitute for volatile organic compounds.

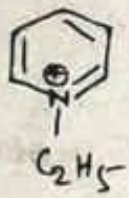
Ionic liquids have following unique properties

a) They are non-volatile
b) They are non-flammable
c) They have high thermal stability
d) They can exist as liquid below the room temperature as well as up to high temperature up to 200°C.

Actually, ionic liquids are liquid salts ie they are such salt which can exist in liquid phase. Here it should not be confused that they are some salts dissolved in liquid.
They are relatively inexpensive to manufacture Usually one or both of the ions is particularly large. They have reduced lattice energy and hence have low melting point.

In 1914, first ionic liquid (at room temp) was discovered, it was $[Et\ NH_3][NO_3]$

Other binary ionic liquids are mixture of $AlCl_3$ and N-alkylpyridinium or 1,3-dialkylimidazolium chloride

ie  or  or 

Limitation →

Recovering the chemical product from the ionic liquid in pure form causes a problem. Water soluble compounds can be easily extracted with water by distillation (compounds with high V.P.) However, compounds having low V.P. may result in decomposition at high temperature.

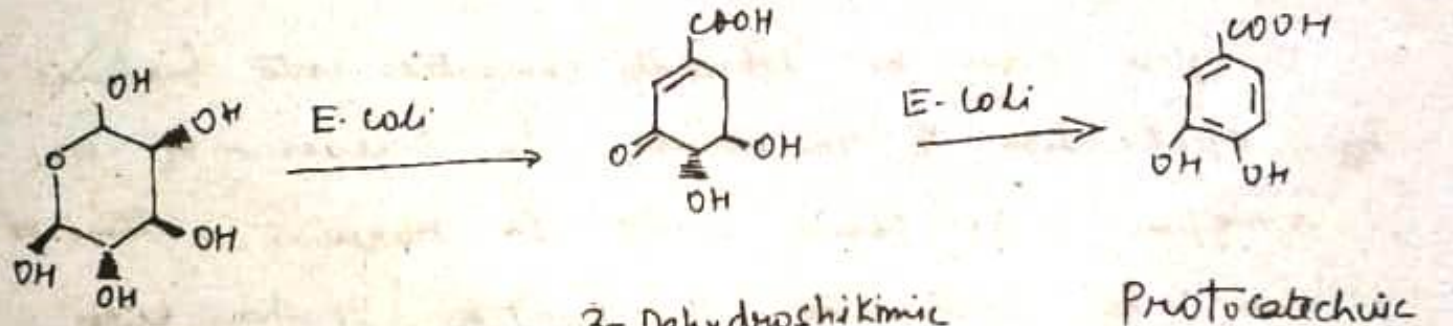
Q Discuss a method for green synthesis of Catechol.

Ans → Catechol can be synthesised from D-glucose with the help of biocatalyst E. Coli (Escherichia coli, a genetically modified microb).

Catechol is readily isolated from the bacterial culture supernant.

The bioconversion lacks completely use of petroleum derived synthetic compounds.

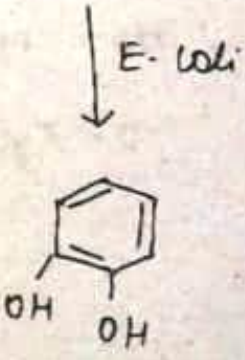
Here, the amount of catechol obtained is about 77% of the calculated theoretical value



D-Glucose

3-Dehydroshikimic acid

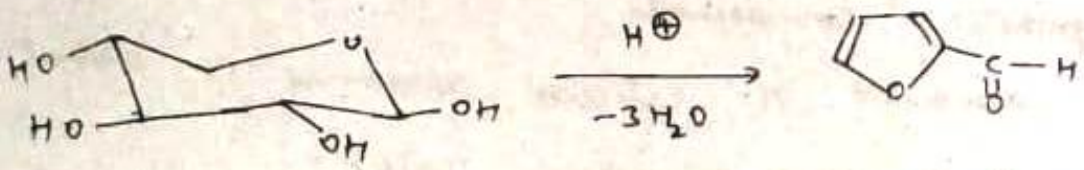
Protocatechuic acid



Catechol

Q Discuss a method for green synthesis of furfural.

Ans → Green synthesis of furfural can be performed as



D- Xylose

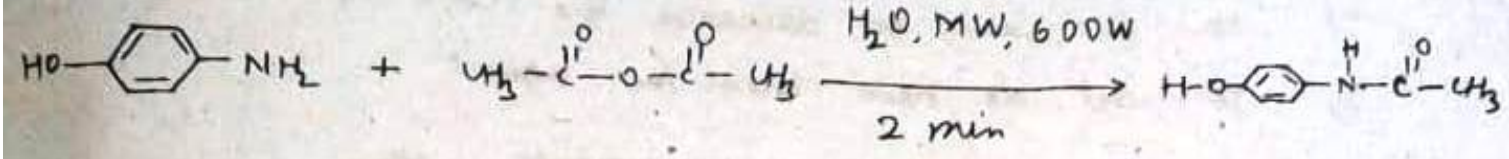
Furfural -2

D-xylose can be efficiently converted into furfural by application of microwave in presence of HCl (4 mg/mL) at about 200°C. It requires a time of 10 min for completion of reaction. It has been observed that 95% of xylose is converted into the product.

D-Xylose is a component of sugarcane bagasse.

Q Discuss a method for green synthesis of paracetamol. 20,

Ans → Green synthesis of paracetamol can be performed as follows:-



4-Aminophenol Acetic anhydride N-acetyl-p-amino phenol

4-Aminophenol is dissolved in distilled water and mixed with acetic anhydride in proportion. The mixture is taken in a glass container (sealed) and subjected under Microwave radiation, 600W, for 2 minutes.

After irradiation, it is cooled by insertion in ice bath and then filtered under reduced pressure The remaining solid was dried and crystallized from minimum amount of hot water. In this method 92.4% of yield was obtained.

This reaction was carried out in volatile organic compound free medium and hence named as Green synthesis.