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16th April, 2024 Chs Alkenes \$ 30, f= n, g= >> Alkanes are non reachne, and they are called paraffins, Par- offismus Assignment (DGH2n+10H+ e 02 -> f Co2 + g H2 0 Altenes/ Olefins -> Addition reactions (Cn Hant CHO + e O2 -> fco2 + gH2 d 1) hydrog en attor Chalogonation find e, f and g (V) Cathanty Coott + e02 -> fco2 + gH2 d (3) Agdrahon Elhydro halegenation Pibords broak m addition Addition Reactions Occidation reations A-A (3) hydroxylanon H-+ CH2) - ty dregeneti an (Ozonolysis X-X (X2) - fialogenation 2 Polymeri Zation Hydrohalogenation Hydranon A- OH Compushion CH3-CH=CH-CH3 Halpt CH3-CH2-CH2-CH2-CH3 QC2 Hy +202 -3 Co2. + 1120 LAS > RHS Arighme thank's is addition reaction, you use 2x = 2x+3 transition metal Catalyst x 2 2 44 CH3-CH ZCH-CH3. Ctta-- t-t-al3 050, Cal Cathy+ (x+y) 02 -> x Co2+ y tho > ctt3 - CH - CH - CH3 AB DCn Hanta -> n (02 + 20+2 +20 H-CH-CH +x02-CH3-CH2-CH-CH #1/H20 20 = 20 + 20+2 It must be nder acidic endition HBC (ii) CH3-CH=CH 2x 2 3n+1 -cth - cth -B 0 Z 30+1 81 Olefic Carbor - CH3 abon CH -CH3 2) Cottanta + 30+10 -> 0 cas+ 20+2-120 CASWORK #/#20 fely -> fra fgth 0 (11) Ctz-Ct=C - CH th 202 -> nco2 + 2n H20 Halls OH. 2×=20+20 30 x (Hoteradate)

Class Cottor recognits 18th April, 2020 Using Mar Founi Kov rale CS= 12 =0+0= R3 minor Mapr đ 13 Hadre Oxidation reaction cH= CH-CHO tydrorybion Ozondysis U 0ª 00 ag, KMD cold of ditute CHZO 0 when sever you See Fridt, H Vio Viam dia autibbA benzaldehigde 22000 dial aton -102-- K4 -11 Mon UB (m) non 2 -OZOE OKT Syn entertion 6) d 420 G-OKO = heptanal 0 Vicinal diot Note that Osa, and KATAO4 furns brown (decolourise) Nde : Π 2 00 00 aq Kinno C=0+0=C ag KMnoy P 6 8 conc Carbonyls 6 H Oxidative Cleanage 20 200 toc Did. 12 57 This will give 3 Ozonolysis ermedicite 7 Cis tus e 205 T 14 00 R-0=0 2 1+98 @CS2 CH3 R2 R2 P3 O. to=c-pt 0-1-14 3 111 (Gzere inserts itself the two olepinic orbon) Poo Cess: al O3 R' 4 R-CZC-R -R3 0 R2-R3 Ra (20mile (intermedicate)

Class 21/231 process Free Back NO2 lath April, 2024 CHN03> No R- E-0-01 cth sou Ott OA Nitects reduction epoxida Hydrolyst NH. (auti arientation) H+/H2 Cdia Óđ Gtt HE Process: herila dt Control. of Anti madicalni Kov 244 Borane ott 024 OBAS/ TAF @ #0/Az 02 product Major Perocide 120 14 HO OH Tille Proces: 3-10 346 HBY P3-B Br 「七〇二件 minor Major tolthe ot Nord Antimater nikes HBC and A perovide HO = HO , HOH 1 Culturnover we add major Mugor A BY IN THE PRESENCE OF PEROKEDE, WE have Ontimer painiFON 1 Polymenization of Alberes (02) HN- &- ctt3 ally 5 6-00 Gt C Para aceta mido phenol polyetiene off Initiators state VZL D. and O 21- Similari pate 1-3 diene

- relain a line NC istrif. ==0 @ dehydrohalugenotion . and in Venyl chlorid El-11 11 13 50 base, heat Styrene Ŀ methoxede Examples CHO ET () CH3-CH2-CH2-Br Questions CH-CH=CH (DOZO nolysis products of 2, 3-dimetry) pentare CH3 CH2 OK+ CH2 CH- CH CH () CH3-CH-CH2-CH3 C= C-C heat CA3 Br ca CH2-CH -CH -CH mojor product 0=C-c-c-c Do C nue CH3 2) Product when CH3 cHBr cH2 CH3 CZCK CZO < C=C reacts with Kott 2ª Ř 2 44 di-substituted R' dh di-Sub. mono Gen inal] substituted tetra COSTON c-E-cH, + KOH subs SUL Zay-1zer Rule stability cH. the the KBY CH3 CH2 CARO CH2 C-CH-CH2 Class D CH. CH-CH, 22nd April, 2024 mino Brai hime out distingly. c43...... DMG Preparation Synthesis of Alkenes NO. THO 300 1000 () dehydro halogenation SWR We 54 9 major 据山H2 Es 2) dehalogenation 5N 2 5112 HOM 7 C2-150 (3) dehydration SNI 13 (3/142) Coott coott (D) dehalogenation 1 acety lation. (M) tor Svit 60 tetta 60 13 So cyclic acid Acetyl Salicyline acid Kolhe - sth midt reaction aspirin 0 10 Naj E-ctl2-cl 0. ch-ch-ch-ch Oalt (2) 3140 J vara 610 to never 142 trutt in an p. J C 07

(Nuthat Lemp will you get allere and what temp Clo-at - c- at Class will you gatether? Unternal parasit Dehydration: Removal of water TEL neeton 2 City City -C= ctt-cH2-CH3 ading the to the the the cH2 a de local 12 cath SOP. = 0 (3) CH3- @H - C - CH3 - CH3 - CH3 - CH3 heat hardfielde has alkene Alcohol CH author Patter honzone' under Ho 5 Hittel 20 0 H2SOF (CH3- CH2 - C (t - CH2 CH3-CZC-CH3 OH 0-C-CH 3 Ctty CHA I mulers 4-cunst 2 Ether can be formed under inter 3 CA2-CH2-C-CH3 CH3-cH2-C=CH 11 4 CH Œ Certain condition of temperature. ano Pseudo CH3 CH3 CH (F) Reduction of algenes another the and C#O reductor 3 CH2-CH2-C-CH2-CH2-CH2 +12504 C= CEC cor albane is Allenis Algeyne heat CO3 Nell CH3 test question * There are times that reduction op allynes CH3 CH2 - CH2 - CH2 - CH2 - CH3 gwes cis alkene or trans alkene, it C#3 CHZ depends on the reagent. Find out the mo enzemich reagent to be used to produce ci's ound MOLEO SO GUL + trans alkenes. 04 Wittig reaction * Study OCT/UN H2504 Sterres chemistry of Alkenes heat from calific hydr * Calin - Ingold - prelog Convention CH CA, Major I cus could ene of formed when got Basop in CH2-CH2 CH2 the presence of quinohine is used as reagent 3 etuyl 2 metyl Trans allane is formed ahan Na and Ling Noting Het-2 is used as rangents the has alli aist Ka

Class 25th April, 2024 O=ortho, m=meta, p= Pura Benzere and Derivativus 0.55 They do not jundingo (cl. addition reach on because the pi-bonds are delocalized 1-2 -dimethylbenzone + * This makes it have now energy 43 - elimetry benz Ormo - Tylene and stubilized Cth * Rather, benzene undergo Substitution reaction Notion. H CH3 H 1, 4- dimetry 1 henzane amere zylen is The daught bond are not really really, they NH2 on pseudo want to notikens Certi aydro zyl borzero aniline 102 of phenol NO2 Allene eresta halo benzene Martin M tos + nino den zene 25m April, 2024+ simit June Benzene my Undergo addition 1 reaction cont but it is not normal: Benzamble ä d oct 3 benzoic acud -cl ast de alters methozy banzare cl study sittiu forsole ∂ a C-H Ct. Pervatives of Benzene and Nomencontine are to phenone ben zaldehyde Handis hugues preforeres 2 Guttetteent nate ademyde 6 ory! t Alfyl benzere methy benzane => 14-hydroxy1-3-method HOT Toluene octa benzaldehyde No barnert Styrene Ving benen (Substitute) > Van illin 20 used methody)

> (rout) 200D CH3 PROS Kigg Mac CEN moundalies Halogenation INU2 O2N-6 Alkylation (Friedel - crafts) Benzonitrile Acylation Cfriedel - crapts) 2 NO2. Nitration 2, 4, 6-trinitro toluene Supphonation tomodensm 10 () Halogenation (prop-2-ana here for Just Merrian Bis CH=CH-Febrarianse 1 4 9 10 -foltx. 3 phenyl prop-2-enal henzer sustituent !! Cinnamaldehyde here -> pheren da U Alcia Told, 0 RH+ PRH To Fro 13 Reactions of Benzene 20014 Mechan Ism. 6:0 0,0200 D Electrophilic Substitution reaction: Sd-Alchs Benzone is as incleophile, having 6: Pi electron. mechanism adduct NE [ALCI4] 100 P stow/ H 0 60 ila (This not stally stable because of the probability 3 ant of resonance #12 E Ase Banzan Sulfair 6120 fast/ooken ł U 4 hydrory zne

(figue Class 26th April, 2029 3 Nitration () Sulphonation 1 to 18 NV2 GAC HNOS 50. Con Hesoy ConC swot ovin 2 mechanism Benzene Sulfonic acid HNOZ and Agoog here are Just reagent palisti () Gidde. mechanism HØ #-0 0=# 0-# 00 HO N D NUT 0 +#59+9# 0 - ott t +H05020 ductorphile + H2 2 (303) Hosozo H60,0 # HSON is bust a reagent not electrophile, 4 SO2 is the electrophile is D 15 electron Sulphu A deficient because the number of Objes 20 ALCIN 05020 h 5 0-3 H-0-5000 SOP Hz OU Probadoro (in) (bugals the 13 + toso 0 3. Benzene sulfonic Gety H 3.5.20

Con why organic Chemistry is important 29th April 2020 mil Class FILL WY BC .. Hydroxy1 Compounds Fight Barry By droxy compounds are compounds with one -Cla Por Ho or more hydroxy) functional groups (-OH) attacked to a saturated carbon atom al_-ct_-a .03 The saturated Carbon atom or a simple alkyl 63 Froup Chlorambucil. used in cancer patrents. It undergoes SN2 Alkanols (Alcohols) reaction with the DNALpurine Altand are hydroxyl compounds of general in Formular of RTOH. The Off group is attached Friedal - crafts Alky lation or bondod to a Saturated carbon atom Gp3 strainling be (A) subjected to ast on alization is the , one plan mistad i subjections (at another in the the span it in build () acid Alfyl benzene (thile there are some in which off will attach to sp2 hydridrzed carbon. Carbon in which Mechanic litito Imeno their off group is attached to Vinying Sp2 is R-cl + AICI3 - R-cl-AICI3 called "enol" while those in which the ->R+ + AICLE -off is bonded to a benzen e ring are , antre referred to as plenols Carbocatio/ electrophile OH If RzcHz or cHzcHp, it will not form Sp2 a carbocation, it will be unstable aliphatt c Phenol alicyclic (cycloherand)) Star in second Glada + An hydride shipt the compations However enois and phenois behave differently A lander then what the rest From alcohols device 3- co per marche alcohols march Ctr 20 Cill-Cill2 CHE -st1.40 Alkands are classified into 3 on the basis of which the off group is banded or landing Lings atlached to. Widow with the point to E and some ship bulled it of a (1) 100 Color 13 her Kanal chidden I paid to Inne archit is bold ask? talenat and sid mall

Class Functional Chen Ban may sto whe Gran- Formular C tastron Examples 7. 10 H-CA-OH CHachEOH must have R-ct-ott CHIOH Shydrager A must have 0 -CH-A CH 3CH-CH 8, CH 3-cH-cth2cH3 two hydrogan CH DH and 2 alkyl 0# OH 0# Group NO hybosen, -ca 3 alfyl goup OH OH terpineo (sudmond) Alkanols CAIZACIA and on shares (D) the of connal names dystems) or findhood these Alcohols can be further classified on te basis of the number of hydroxyl groups per This is good for simple alkanut molecule or How? Name, the altyl group (R) and follow the word atout attached to Aufferent carbon ato ms. (1) Mono hydric: contain only one -off per mole cule Frample in CH3= OH methyl aleohor ? Dihydre I contains two -off per (4) CHattaoth ethyl abcokel? molecule - The @ alg- ch -ot Elling Sunglest ts Ethane - 1-2-diol (gly cov CH tet-bityl alcohol) (t-bityl alcohol) CH2-OH Common 150 propyl abohol CH2 OH 2. 600 0 CH3-CH-CH2 CH2 CH2 CH3. L-CL + AICH 04 9 Example methy) Pentyl alcohol CARBING SISTER mamin his system of atoshol Considers all alcohole to have been derived from methy alcohol by the replacement of one or more therights hydrogen atop by other groups: PULOS! A0 Cholesterol alcohol Dotors the group (s) attached to the auton bearing the 2 is Vowal) Off group and then add the supply courbind to depice the 21ms bas (3) Trihydric i per milecule contains. Coll partion. Example 3-00 Example: Propan - 1, 2, 3- tiol (gly derol) (1) (1) CH3CH2CH2M -OH -0# CH_CH_2 of GH2= ptt bein Propyl Carbod etuyle carbino) Propy car binol off OTI (u) (A) Polyhydric i More than 3 or many -of per moleculo 6 W Ctlgct-2-CH2CH2 00 diethy 1 Carbinol Normichtur There are three important system used in none alcohols. Triphang an brol

30th April, 2029 3 (3) JUPAC SYSTEM: This is he most Varsatile (2) that the call of (2) System of naming alabols. Simple accords are 40-0.112.000 named by the Juppac as derivatives of purent Ctty C-CH-CH3 alkane using the surfix -ol. 6 cth-d= CHIZ Rules Followed in Naming Using Tupac 900 M.M. L. 40 Select or consider the longest or continuous Carbon X-A cH- CH 000 (7) chain containing the - of group in deriving OH OH xH + 110-9 <== 01-1-12-9 (1) the parent nome Physical Properties of Alternols (Number the alkane chan, begining and the end nearer the -OA group so as to give carbon (1) Altanois have high boiling pombat 100m temperature atom to which the -ott functional group is 2) They are miscible or soluble on attached the lowest possible numbers Where way to High Hogo manualant Examples Ctta Frank -All these physical properties can be at () CH3CH2 - C- CH2OH cliz explained in terms of internalecular 2, 2- dimethy butanolhydrogen bond 9 400 AI teparations of Alkanols 0 - CH2CH2OH 10 n's () fydration of Olepus Alteres: This . 2 phenyl ethanol uniolises i treatment of oligins or alkenes With cold Hason followed by addition 3 of water and hoat. cyclo propanol Altand -1 depag 10 Lator ogo let 4) QZ= c+ H2SONT ang) -ctb 2,3-dimetuylayclooctinol -(#3 050, H Andre #20 Questions There of >-C-C-C- to the Sopla policit with a white the (Atte 3) pattorna otti 0 80. H259 - CH3- F# - CH3 (H) Cth3 ct = CA Linity / etc Of SI ctts ott 0502# 0 .(4 ctt3 CH3-CH-CH3 + H2504 HLAL Last 5 - Chard Porch to 221-11

I: AA Ata 2024 (2) flydrolysis of Altyl Haurdes (R-x) by (3) Hydrolysis of Esters. This hydrolysis can be acid catabed or albuhre SN Catalgred R-of fthx RCOOH + ROH + #20: op P-01 + KX two steps R-x fkoll Mot RCOONA + R'ott Process O B-x - F Kto = R-off + the () HX + KOH = KX + H20 This also involves two augs D ROOOR + HO = PCOOH + PON D BCOOH + NOOH = RCOONA + HLO > ROOR + Nach = ROONA + R'OH Meelunism of Hydrolysis Example The mechanism of Alkaline hydrolysis an be SNI or SN2 11 10 çu, CH2-of COOH + the E ct - ott R-X 10, 20, 3° J Ct2-off CH2-OA P'coot CH2-30 SNatingreases 10 240th Rook Triggcertol CH-OH + R'OO K* Fir terthany alky halides, Mixtures are (fat & oil R"OUK* often impossions are often found with the CH -OH major product being alkenes Reduction of Carbonyl Compounds Calde hydes kott > Alkanol appli ketones): The raduction of aldely des + olefins reflux MINTOT major and kennes involves the usual reducing Here, The formation of alkenes or defines agent such as theft the with catalyst eg the At to by elimination process lie El which i 0 or talld or Halvi Competing with Substitution process, SNI apply D Chemical reducing agent e.g. Na Bthe letter CH. c-ott + ctt c=ctt2 > CH3or attached, LiAlty/ether the ne flux CH red and major CH3 - CH M CH13 + 16 50. Note that LiAl Hy is a very powerful Nedwing agent. It reduces - cfto los tona A allongo

Roop' and C=C. Esters: Esters WILL groud two types ap Alkanois will powerful reducing agent. If Matto Sadium more hydroide (a mild However, NaBHA is a milder than LiAlty reducing agent is used. No reaction occurs aldelights & rutone, but no effect reduces or reduction may be very slow. on ROOP as well as C= C Hence, medium alyminium hydride is used sters; Prote Err shite, marine ence the president to alterate LiAlty lether. > R=ct off + R-off ishunshin diril (RO 2nd May, 2020 [#+] OR! inothis domini ALDEHYDES: Se late Er Norman ein -113+ On roduction Note that one of the products Must be 19 Q-CH2OH H2/Ni> Primary alcoholy while the others depends (alcohol on the prejo nature of the Rt and Tank it LiAL By letter Agres this is e.g. bi diat borene. otri NaBHy/ettal Vi O meranol eg has an adjustical of contractor Idiph hor Port in withto LiAlty letters disctistic the NaBAy Moth No nho cthat 2 ctd ne is non-selactive CHJ . R-CH2-CH2-I (reducing agent) R-OH = GA. ut-2-ene-tal Exercise Here Hickory FRAND 4 Afthe letter NoBAq/eta Ctall zatacth off 0 CH3CH = CHC Tor PaBHy/ mothanel (most) Gt_ Co CH2CH3 (Gelective reducing agent) Das 2 sal 57 0 Nº4 1.01.19 EN3 (Charles KETONES ! Fetones on reduction will yield 010,40 Secondary alcohols Ho C-O CASER NasA4/meot f2/Ni R-dl-F Reduction of Carboxy he add es=10,11 Li Alty (etca ot 6 Orcho M 2º alcohol The behave in a similar manner to estars. NaB#q/meot Carbozylic acids are reduced to primary alorhole a lunbort à d a single product) with LiAlthy (in etter abile eg 1 LiAl Hy etter there is no reaction NaBHy in medit NaBHy met aycto pentinol Gdo pentanon

CH Pratut, Rall201 Rcoot Preparation of Alcohol From Grigmind LI Althe / etci Reagent: Griganid rangent is used CAJ in the synthesis in the proparation of all no ixn the three type of alcohols (1, 2, 5°) NaBAL MeOH The grignard reagent, are reacted with 2.9 LiAl Asletur carbony) compound Caldehydes and ketones) CH3 CH2CH2 OH CH3 CH2 C esters, epoxide to for intermeditate which are further hydrolyzed to alkanols D With aldehydes & Ketones. (1) Hydrobolation: This reaction is also used +RMgX dyeta 20 convert alkene to alcohols. et. M nucleonia (CH3CH3) It is g two step reaction process, in that electrophilic the first step is conversion of alkane is O-Mgx into trialkente borane. Again, this is Converted to alcohol in the second sterp MyOHX The next reaction is an anti Mar pounitor addition in Water across the double bond This method has an advantage of extending 10 660 the carbon chain 8+13 -> (R-c+12-c+2) R-ct = cth (term hydroform, (Trialky) borane) dry etters (thatta),6 Ho2 Nat R-C#2-C#2-0# of + Mg off alcohol 13,350 1- alcohel (+1c-atom) () Convert 1 propere to 1 propanol H202 Mad ctt3ctsch-oH BH&> (CH3CH2CH2)-B Epoky et on e Cethylone oxide) my be wood CH3CH=CH2 THF instead of methanol 1- mopene (Convert 2 butere to 2 betano) ty day Acts CH 2 OMg x Rog X H2C-CH2 epoxy ethre BH3 > (CH3-CH2-CH)-B CH2 CH2 CH 北京 1 4 1 1 HO/H RCH2CH2OH + Mg OHX 2- biters-1° alcohol (1000 atma) H202 Wast CH3 CH3 CH (+2 Catur) Til - MAL Ban +hdain

With Epoxide: The reaction of grignard dy etter C_ 8mgx Rmgx reagent and epoxide gives a primary altanol 0=0 with two carbon atoms added -of + mg ox R-CH2CH2Omgx 2° alcohol RMgX at it to 311 May, 2029 RCH2CH2-OH+ Mg(OH)X In the proparation of tertitary deched, aqueous 5 . 15 1-alcohol NAUCH is used for hydrolysis as dilute acid How do you prepare propanol from a named brings about debydration of eet 20 +++) of grighted reagent the atomat to alkere In Summary Grippad Reagent F methand -2) with fatars > l'alcohd The reaction of grignard reagent and esters 13. 12-11 PETE other aldehyde -> nº alconde 3° alcohol quies tertiary alteral as the product. It is a Stale Ketoe estus -> Ketone -> 3°delaha two step reaction. The first step, gives ketone. erande >>> 1º alechol R Mg & dry etc Romax R' 1 CILLAN MAL RMAX HD/AHARI Of p-Img(ott) Preparation of Avomatic Alcohol (D) Aromotic advolial can be prepured by dry etter CH2CH2-C + Clym Br Cannizaro an. Aromatic aldehyde, Such as + octta 0 benzaldehyde, It when shaten with aqueous Kett. it under goes simultaneous dry ether 0 6 diff. Oridation and reduction Consproportionation reaction) yielding the potasium salt of the corresponding carboxylic actid together with the aromatic albond reduction li Se-ok 0=050# PKott potestum benzent. Phenyl methanil

E anxing: The potassium salt is dissolved in water and the that stabilizes the RO more than it stabilizes m. the Rott chould increase acidenty and vice Verset alcohol is extracted with exhory) ethane (ethage) (dietuglether) using seperating funnel. Therefore negative inductive effect in 3) Hybrolysis of Chloromethyl benzere (Benzyl Chlorette) R should disperse the negative charge and Benade Chloride is readily hydrolysed on Stabilizes the Rolf and thus increases acidity. On the Other hand, positive boiling with aqueous alkali to give phony ! ethnol inductive effect in R should intensify Ctott the negrative change on CROI, Men stabilizer cthal I day Fint the anions (RO) and this dearage tKel PKOH 0 acidity 1 Gib may south the The addity of alkands it shown by their NAME (T reaction with active metals to liberate the gus and D By reduction of Benzone Carboxylate (Benzooto) give the metal alkoxides 2Na + 2the -> 2Natt and + the Banzy manborghic and Chanzon acid) or ether benzoate an be reduced to the alcohol by 2Na +2R-OH >> 2RONA+ + H2 Using LiAlty (redularing agent) Example RO-H + 2 M -> 2R 0 M + H2 g) O pct 20tz CHLOW + CHGH-OH Where M is motal [H] > 0 actt act of + 2Na - Dectact and + Had LiAl Hapletor The star of the main again Ginalt As a base. Alkanoi accepts a porten wavy 4. Charorical Reactivies of Altanol love pour of electron 61 organ atom. Alkanols have Anghoteric behaviour. Altanois? A-OH + HP -> Aut -> roxin un conact as an acid and a base The basicity of alkanol 15 shown by the () As an addi An alcohol releases a proton foretop of hydrogen haldles to give and in the service install its ally found es (Px) ROH RO PHT 5600 acid Congrigle base Rott + Hx alkory >PX F AD This nest among down Order of acidity: \$207 altrott > 1° alcord 7 2° alcord 7 2° alcord 7 3° alcord HI reacts must rapidly; While Hel least apply and requires the presence Acadoty depends on well the conjugate base (RO) of Zne delarthe for reaching with Con accompliate the negative charge. Any factor thomas multiples Grader

oily homogeneous 1-yer Mechanism of Reaction primury and Secondary altane) 20 nodespect The mechanism of the reaction between and But conce Hel at room temperature is right for alkanol and HX is SNA except for ertany alkanols. This test is called methonial and most primary altanol where was test for altan als NO. The station pour / boiling prist of SN2 is meleried. Andora fistanth-c SNI mechanism involves 3 major sheps; The ZAC City ctta Cta Of + Hel -Ctt 3 cth cth cl (Dprotonation of Alranet to for oxonium 5.11 ion (the of) tracks solutile in Break Schutch Dissociation of the protonated Alkanol into 1 dry ele and a carboncation (i) The Buder go Water Nab / Hasop bild (m) Combination of the carbocation or rearranged 1.A the north Centrocation with halide con (x-) to? 72#81 \$ H2 SOLP form the altyl hairdenting bimurizens must of 4 cft3 ta dil D 221 ++x +> Roth + X-Conc HCI 13 -0 ROH 0 dł, (F C#3 + 2 + = Pt slow Ct)-+420 (ID 3° alconol Propuding (2 DAX (II) Note Othe reaction "it catalyzed by cald. Str att 4. The slow one is the rate determing step ! Conc. Hasop Consisting of only one molecture i.e. R-dt Terefor (I) Rearrangement of alby) group may ocur H is SNI Cummolocular except with some primary alkanol Aibul ZnCla 101 Examples 1 E's- C-cH3 + Hel -CH3 ctt oft + H-cl = -Ctty dl - 01 CH A OH CHS lowst (Doin C#3 CH3 fcl ncla poor ct ot + He -cth_cth_ dł. H2 Q CH3 CU d the CH2 CH - 00 0) Order of Reactivity of Alkand Toward C CA2 Hy altogen Halales Das car bilato ×Inci CH jot Benzyl, Ally1 372 ctacl 7 DII SNZ CH 02 SNI Constitutional mina product o C# 2-0 200 CH Etta- cH-cH2 - Allylic atc - CH = CH2 - Ninglic () chiain ici 107 207 CU mapr Oty callet Loon no Gu Cthy-10 callel Acyclic for most primary alternol and methanol the formation of 0 primary carbocation à veg slow because of the poor accomdate of Posteria charge, Hencer Elmolecular extract os un hadered As -Clt2 - Cl = CH2 2 3

1-2 SN2 is fast @ Dehydration of Allhanols: Phys It gives alkenes, if here is a > ROH total dehydration or alkozyalkaner 19 SN3 there is partial dehydration. The common reagent for dehydration transition state 13 conc. H2 Soy or H3POy (ortuphophing actil or phosphoric actil Also, aluming R + H20 (Al2O2), with heat in the slow sep showing that the 2 spects the machanism is bimdecular. 7th+ May, 2020 # Order of dy hydration Alkanol can also be converted to ally !! halides by reachen with thionyl chloride (Soch $3^{\circ} > 2^{\circ} > 1^{\circ} > ct_3 ott$ or prospherus penta amoride (pcls) or pcl3 The reaction in the absence of a nucleophile a start when the second Concess conc. Hasoy) gives alefin. The Rot + SOCI2 -> Rel + Hel + SO2 00 Ron + Pols -> Rd + Holy + Poch intermediate carbocation may reanange to a more stable one in form of 1, 2 hydride shift or 1, 2, ally (shift before 3 ROH & POR3 -> R-X + PCOH3 losing a proton in the adjacent orboy any of halines atom to form olofin 12 An 07 mg. The advantage of the third reaction over The above carbocation is susceptible to attack by nucleophile, hence if others is that it does not contain excess alkanol is used, the alkanol Contaminant as gases. T may act as the nucleophile because of The steamy white fimes with pols Contains noticates presence of alt group the excess lone pair of lone pair of in a compound, especially alterols and electron on the oxygen atom alkanonic and 0 RCH-OH+RCH2-ZRCH2-03CH2R RC + Pas > RCici -> RGH2 - O- CH2R

Formation of Estars (estarification) Phonol aleneral Reaction 3 H20 + Htak Alkohols and carborylic acid reacts in the Presence of mineral acid eng Conc- Has soy "It sight . ft 27151 Alkene catalyst to give esters altanol . 10 H1 1100 14 DOWN CLAND 1582 H+ . > 0 818-OR-off +R-OR NTA PRESS off reflax anna d'a tama aikand also react with acid chloride Tabur 2 Alcohol an R-O-R Cetter) R OR-Rott ttcle che wister R. 1. 201 1 1 Sol Zi Kalad OR Depending on the condition of 1 acto chloredo snel. die 1 VISUAT dehydration, alkanols may give two Charter S. DR. types of product in in LADGOSE \$v 12 RCODH exers Core Absorp ROH Altere 1800 acid an hydride (i) Conc. Assop Alkozyalkane Cotor ROH 15°C @ Station Examplesing on bullion Whisper out els malati Reaction algia It Alcohols Can couldized by various oxidizing C-CHOCH = (CH3) C-CH Oth (CH3) C- CH Cigent : 4205 O Alderyde () Kotone (11) Carborylic acid ending on the nature mOL C- CH2 CH3 - CH2CH3 CHa and the strength of alcohol the 021212 que agent use -117 . 2013 + CH3-C= C#CH3 Ctz, PCC strag ozeberg gent med anithing cts major product miner - LAbets EKA (CH3)3-Paci20, 14250 cts EAU ctt3 Secondary alcohol are oxidized to ketone T -cH2 CH2-" CH2-0-E-Under normal condition CHA 50.01/Hts watter Ri - [24] 11-2 Ketone CH3 CH2 Oll 411 2-hydrocy) propone Contitues latine 212Hand 15% 12/yd

The Ketore formed has to Undego prolonged and Phenol drastic treatment because it as be broken down into carls Phenols are hydroxy ampounds all with general 15 ayla preny) formular Ar-Ott, where Ar with smaller number of could an actoms Tertiany alcohols are normally resistant to group. Plands, differs from alganols in having the -Ott group directly attacked to an Detidation, in both neutral and alkaline medium because it will involve the breakage of the high energy c-c aromatic ring. Like alcohols, they may bonds in the alcohol more hydric of polyhydric, depending en Of group that they antain NO CRO NIDEL of The chemistry 14 9 of phenol is very different 4 3 alcohol From that of alcohols. A phenolic compained Havever, in actile solutions, tertiary alcoholian be hexachlorophene is consituent of mouth washes oridized to give a mixture of letone and acids loobs stin deenser deordorant Solard meditinal with fewer Carbon ston. For example 105 activities cth Cth = + ctscoott alphab b 1j capet in (5) Haloform Reaction: Alcohols which contain the Phenols are generally named as derivatives of group chesche can be or id red under suitable and its the simplest member of the family, Phenol CH3 - Chit group of alcohol weil readily occasionally phends are ramed as hydroce compounds. The metry phenels are knowns as Undergo haloform reaction with CRESOLS Cttx NOOMS RECOND + Wheekz Br cth P-archi Haloform I,cl con Note that Flourine aninot be a reagent to 4-metury Plend or the -420 2 moting [plead) 2 = hydroxy bezon halofonn reaction Patta: - cresol med on dine Cational acid Kample (Hydroquinure) CH3-CH-CH3+45 23 cth + SHI Ed - C Ó ott NaOH ON. benzene - 1,4-dia) J30.+C 2 - naphtio) -Ct - naphthol iodo form Griodement CHIZ is a yellow ppt with antiseptic smell The halo form reaction take place in step 1 (Steps i () orcidation of the according to an aldehude of bothe (2) Substitution of the halogen atom in the motion group (3) Hydro lysis Under alkaline Condition to form the hab form.

Class 10th May, 202.0 Preparation of Phenetrening Be D By Piffusion of Anomatic Sulphonic The cholobenzene formed is then contralytically salt with an alkaline solution e-g Nnott hydrolysed by passing to with deady Steam over silven catalyst at 425°C Soz Na 2. Naott 300-350°c Sim and Of t Helcast salum -f the Cago mencaricle + Na2503 + H20 (4) by hydrilysis of diazonioun sout. In the The phend is obtained as an oily liquid by Lab, heating of solution of benzene dissolving sodium phenice in a sodifierdy water and diazonrum salten a worter bath at soc acidified. ong yields phenol -NENK + 21/20 50°c > F. Ng+40 0 where x z cl, Br, I. The phenol is recovered by steam. 502NA ont + Ngsoz + FLO distillation and extracted with evetworky brane Naot 300°C (dietydeter) Using Seperating funnel 0 lab () Primary aromatic amine with cold nitrous acid in the presence of strong mineral acids to B-nettrhol give dipazonium salt. The process is By hydrolysis of chlorobenzere: Hydrolysis of Frown as dia zotration Nto Chlorobenzene by aqueous Naot at 360°C NE NCI NaNOs ARL and 150 atm + Nach + 120 0 O H azonium Dag. Notdil. Hel 360°C, 1500km Reaction of diazonium But with water Will now give us phonol B by Fasching process: Here, benzene is NENCI togater chlorinenated by passing the vapour (DA20 6 FN2 FAct 0 058 way Hclgas and air over a heated culla Catalyst ab 230°c 20 + Hclop + 02 g 2301 0 +2 120

contre S fam proton au actua Reactions of phenol we make adhated than other position, therefore The reactions of phenol in cloudes the following' electrophilic attack of the benzene ring will D Acidity of Phenol DEher formation (Will ranson Synthesis) octur at orthe and pire position -Electron withdrawing group such as EN; ct CO (ii) Estar formation NOs, attacked to ortho and para position (1) Ring substitution reaction e.g Nitration, Supporting Stabilized the phenoxide and thus increase hologenation, friedal craft acylation, coupling with diazoniun salt, carbonation, formy lation acidity . On the hand, electron donating group Acidity of Prend (A) attached to ortho and para plenols are tremediously more acidic than Position of phenol destabilizes alkanol but Carboxy lik acid : 11 Phenoxide ion and therefore decreases Order of acidity! auty RCOOH > Phenol > alkanols CN OH CN This shows that the off group attached to an aromatic ring is more acidite Than hat attacked to an alky I group a.B.Co ctta ASLADI ANDAN ctb cHz 13th May 2020 monola : notistia Phenol as an acrd." with this 2 in rist (2) x of 12(2) CUT order of wardity E<D<ACB,<C Q(CDAD) the acidity of phenol is demustrated The reason why phenol is mae addic is His ability to form sults with allealine ecouse of stabilization of phenoxide ion alun bases such as NaoH / Kott O-HAL OTHER LEADER PLANE + NaoH 2150 10solition acception interview 2) Will i amson's Synthesis (formation of readily If compared with alcoholy ROH = RO + H+ strend; Thends in the prosence of alkalin not ftabilited 102 base (NaOH/KOH) reacts with faloalane In the resonace stabilization of phenoxide ions, to form alloory etuanal etier Score Nor & Products Pusition 24/ and 6 1-2 orth and para position

Ortho & para Rosition are active an tanada 15 znam Prenot 0 BO as the has been eliminated as a gu 0 0 ot -026-01 0 - OR +X -0 + R-X (1) halealkore SN2 reaction This is an 0 2) e de Serieda Mechanom: (SN2) + CF2 COCI 8. slow RX (4) Ring Substitution : The off group attaches O-R tx ben zene ring in phenol activate to the the ring powerfully and direct ortho and para in electrophilic aromatic substitution Example + H20 e CH3CH2Br. -O CHLAH3 NaBy (Nitration: Monosubortuded Compound of (5) Ester formation Obtain ed with dilute HNOS at room temperatur V2115122 40 1.21.70 Phenols reacts with carboxy lik acid det. ANO3 NO2 anhydride (RCD) acetyl chloride 2000 R E-cl to form esters Octo nitro plenul No Prantopen unter carbozytes acid anhydride + RCOOH Pilute HNO3 at 20°C Will a crivate the reaction P-C unline ordinary benzene which requires conce this 0 C 20 This is due to extra reactivity of the ring by Hard -OH group. with acept chlowde However, with cone HN 03, when the substituted Product is obtained readily R-Correct + #41 0 A concentration of Non Non The second reaction its pre-ferable because the resonace stabilized of does not need Seperation of products 2, 4,6 (trinitroplayed minison

(iv) Friedal - Crafts Alkylamoo/Acglation (Alfylanon (1) Sulphonation: When prend is treated with Proprie Marris Done Hasser Different substituted product will + R-X fects to attend depending on the reaction temperature. -Ofallylphonel 1-atry penos Corr. H2 SUP Soatt 20°C major produt 6 Acylanon Dr. H2SU ALCI 100 00 10:31 20 nautist P. Pheno Suiphonit acid Foduct is temperature dependent it Busing to translature of the ortho product Acylation is used for the preparation of to 100°C will gread the pure product phenolic ketones and this preparation occus instead by means of frees rearrangement (i) Halayenanon: Pieno I reacts with aqueons of direct substitution on the Solution of halogens to give polysubstituted product It goes through two steps; Offormation of 1st phenyl ester a) migration of the acul group from (ma) the phenolic group to the De ortho and Position of the ring 2rt, 6 tribrene preno? The rearrangement appears in involve generation of agilium ion To the reaction is carried out in a solvent then attack the ving as in ordinary of low polarity such as CCS, ccly and alloroform (cHclz) The reaction predo 1 Craft couch on can be limited to more halogenation () Nitrasation 10 1211 2idvor. QU NaNO2/HE + Br 2 any) O'c Feels Q To V QH H - nitro sopheno 1 The nitroso product is readily oscielezed orsolvent Mujor Adut -Polanty The righ is degendent .

112 ASTUM - ACOUNTY - MAN Mechanism 23 the corresponding nitro compound by HNO3 0=2-00 olt HNO 04 0 D ioe coub NZO p-nitopheno) 0 (1) Coupling op Di alo n'um (synthens of AZO Pyes) The With tonzone dearonium salt, phenolo Couples to give AZO compound. For this Va Aldeligde formation Grony lution) reaction, a benzene diaxonim Sult tormy lateon which is the in production of to the ring can group NENCE -CHO 60 in two ways oft D 0 0 Reimer Tiemann @ By 4 - Hydroxy Henryl azobenzene reaction yellow pecipitate) Congne ctich Ocq North 40 10 Note: In preparation op 0 die CH 14. Plenol + Diazonium Salt 0 CHO This reaction is very important in dye stuff 0- hydrozyponzenie Qubaldehyde industry because Azo compounds In the absence of chloreform (col) Very deep Colous Asignment USe ccly Diazonium satt Cuerg day 0 Using cely instead of choroform 0 the reaction will yout carbosylic and donvatul (artis) (Vu) Carbonation (Kolbe Schmit reaction) O og Noot OH A f cclup Ad He Sodium peneride is heated with Camon Childoxide LCOOH COONS ay Noath 002 8 The main use 725°54-720 0-9.010 SIN ryhic 6 dit tel is its conversion to aspirin chief predict 2 hydrozyl benzo heating it with strands or (Commer couldy know of) agety anhydride 11 Lansking stin the shi art ic 171 The ran -7 in his

Reduction 13 JUSPER Inste Rhends are reduced to the correspeding + CH30 aromatic hydrocarbon by distilling coot high tom at COOT Lonc. HSE + (H30) CHI Commonly known as aspring 20/619 temp satire henzone Gattermann - Koch Peaction allehiles and Fetoms 100031 0 OAICIS CHO 10 16th May, 2020 Wile HON Carbonyl Compounds DUST Orthe- almost 100% (Carbony) compounds consists of addingtes and latoros as they both contain = 20 If the other proton of plend is blocked by functional group. a group, then, forgylation may be caused This carbony | punctional group in both formed at the para position addhyde and retare are sp2 hybridized where Ror 0=0 may be alleyl or and ally groups. A Aldehyde Dia 12 Oxidation Elends are easily oridized by Fecl Popan or Kacia all Ht to quino nes acconexanone Fecla Ditter Oxidiana andite 1,4, benzoquinon Therefore, they have of and IT pito ord. Assant They are generally very registive because of the pie bond and the polarization C=0 bond. However, aldebydes of 10110 are generally more reactive, being more 1, 2, benzoquinne Carolat! easily oxidized and also more so Susceptible to nucleophilic addition reaction i.e. electrophile

Note intest Physical Pioperty of Aldelighte & Kotone (They are mostly colourless layened and (B) By Ozonolysis of Allenes: Alteres toom fomperature, especially the simple reacts with ozone to form ozonude aldeligdes and kotone. The lawar which on hydrolysis in the presence allelydes poccess rather uppleasant of zinc lacetic acid or water gives Rungent smell, whereas betones and ketone or aldely de also ben zaldehyde have sweet adours R" Os S N ZAKE CONTO The lower aldehydes and Fetones are Ozonide appreciably Soluble (miscible) in water due targely to therability to form hydrogen bond with the water molecule - x anton which Kall 200 20051001 (5) The lower alliphatic aldelighte and kelleness e.g eta have boiling point because of hydrogen 03 15 high and retens and so spirit a zalchz Coott -ctt2-ctl2-ctt2-c=0 Preparations of Alkanals and Kotonis 5-oxo hoy ang D by widdization of primary and Secondary alcohols: Primary alkanols is mildly 3 Catalytic hydrogen of altanol: When Oridized will give alde hydes while ... Vapour of primary alcoupt as passed Secondary alpanols will yteld ketones over heated copper, a concesponding However, exidation of primary alkanols aldehyde is produced. However, a often lead to arboxylic racid when secondary al cohot will give Similar Strong oxidizing agent is used, Pet reaction. on porn is a better Oxidizing agent on H-CH2-Of CH Soor C=0+H2 the conversion of alcouds with lacohol R-CH2-OH POCIES R - CO CH3-CH2 -CH 1° alcohol ? -Cfl 2º alconst butanone - Paciforn bretan 2001 Chetone Colo 14-M

17th May, 2023

(4) Reduction of Agil Chloride (For aldohydes Chemical Reactions of Aldehydes & Ketones (1) Nucleophilic Addition : Aldehydes and kerones only) : Fetores Gn bot be prepared with this method. Agl chloride Unlego mostly nucle ophilic addition - This is the 15 hydrogenated in the presence of pd addition of nucleophile and proton access the Supported over Basoy. In practice 220, the nucleophilic addition Polarized the pd catalyst is possoned with an occur in both basic and acidic medium sulphur to prevent the reduction process ·Na 8 from going to alconol. C- PN4 Pd/Bases NU agl cheorrde This reaction is referred to Rosenmond (reduction Hydration of Altyne: Mothyl Ketenes Can be prepared by hydrotion of (B) Based Catalyzed aduli'h on: Here, a strong terminal alkynes in the presence of alforade which is the protonated. Mercury salt as catalyst Ottasa As c-ct 3 (b) Acid catalyzed addition: Here, the acid protonales + # 0 eno carbonyl orygen after which weak (very stable) CH3C-cH3 puckeophile attacks the carbong 7 Ty) Hydration of Aldehydes and Ketones. +H20 -># ACZCH (ethunol) Aldehydes and ketones react with worder both acidic and basic medium to form didly i.e a germinal didl. The reaction H-E-CH, is reversible and the backward reaction is (aldehyde) more favoured. to save the and of in the of -H20 Z 1 1- diol 0=11+K-11+

Mechanism Alendo Ferales to-H >Ht (2) Reaction of Ammonta Derivative Hoi Some demative of ammonia reals oth with adde hyde and before to form compound with elemination of water molecule OH @ Reaction with primary Amine: Primary sH-dt 0# unine reacts with aldehyde and be to re - of OH give Imine OF > C=N-R + 1/20 C=6+ 43N-R inin amin Addition of HCN Atteligdes and betones reacts with Hot to (b) Reaction with hydrylamine (How-on). form cyanohydrin. The reaction is base = N-0H + HD 0 +H2N-OH (=0 Catalyzed, a poisoneds gas is generated oncime in situ by the action of dilute Hassy on KCIN or NACN @ Reach on with Byetra Zme CHON-NH2 CNO Ot KON/H2SOH > CZN-NH2 CN CN tof HIN-NA2 Agdrazine hydra zono Gyanohydrin Chydroxy alkanohydrile (2) Reachen with phony hydra zine Like other nitriles, 2-hydroxy) alkan onitrile Can be hydrolyzed to form the carboxylic acid = 0 + H=Nderivative. In this ase, the 2 - or & - hydrozy aprils. 0 0 Conc. Hcj > R-E- COOH R-C-CN Phenyl hydrozone !!! reflux, soe Jan Reacher with Semi Carbon zide Form 2 hydroxy propanoic acid TO ott i) concilicity city ~ c- coolt Han >dt+C. C.H CN C=0+HIN-N-C-NH2 CH3 2-hydroryl propulace N-N- 2-NH Addition reaction occuring simultaneously with Somi carbozone the loss of water 3) Reaction with Alcond. Aldehyde C=0 + H2N-Y -> =N-Y+ H20 and before utsoct with equitalent 7. 2,4 DNP - OH) - hydro my amone al co to 1 to form acetals = NH2 (HEN -NH3) - Hydrazone

whitch are germinal disther Methyl Ketones or any group that can be oncidized with alizanol will react j=0 + ROH H+ - C- Rott - C-alcohol OR OR rapidly with mlagen (CI, Br, I) to acetal form baloform and a salt of carbozylic Example acid CH3/CH + 2 CH3CH2 CH3-C-4 + 3Br3 + Nabt 2> R-CONA+ 20H och₂ch $2 CH_3 - C - H$ CH3CH20H OCH2CH3 If Iodine is used, it give yellow precipitate with a characteristic, adams EReactions with Tollen's Reagent: This and distinguishable odour. This is a reaction is for aldehydes only. Aldehydes diagonistic test for matural carbonyl reads with token's reagent to give a Compound. deposit of silver (silver murror test), to Arfferent between addehydes and ketones. The reagent ansists of a solution of Silver constrate in excess ammonia solution. Aldehydos reduce the Agt to Ag, which is precipitated and forms a mirror effect in the bottom of a test tube. -Fhanal reacts almost immediately, but with benzaldehyde, the reaction mixture requires Warming, but does not CH3- 6 +2 Ag (NH2) 0H -> CH3 COO NH2 +2Ag H +2 Ag (NH2) 0H -> CH3 COO NH2 +2Ag Silver + H20 +3NH3 cg) LOVEH + 12 -7 TO-COONHY + 2Agos +thot3NHza (F) Haloform Reaction: Compounds with Methyl carbonyl group such as opparent and

21st May, 2021 Formation of Aard Chlorine ¢ Carboxylic Acid Assignment Delitrite the mechanisma for the formation -coott of agi chioride. E-ott F HP 0 Congriget proton acid coot an be involved in acid-buse reaction REC. Reaction. >R-2-01+ H20 R-C-d so +Hel OHA SOCIA R-E-OH TNOOH nerter acid. Chlorido Salt thonyl Carborytre has acri alkanote/ chloride allever and carbo gylate oci Carbony lit ceid Fisher estenfocation is difficult, this is easy Nucleophilic Agi Substitution -> acid -> ester chloride 113.11 Carborylic -ott 13 -OH NUC Earberry in and the way NU betrahedral, Lufficult inter mediate 23rd May, 2029 of Hell - Volhard - Zelinsky Reaction product R-cH2-cH2- C-OH HUZ R-ctt2-Ct2-C-Ott. + R-0 + >> - 0p + HO mechanism grat 1 1 -OH = Q-R -OH Assignment A Write the mechanism for Hell-Volhard-E-RH OH Zelinsky reaching 0 We + Lin--OR R- C-04 + NaHCO3 -> R- C-0 Wat + #20 - 0-R' + # 0 +002 #-0-R' 6H_ 10-2-2 -Affor Vascince formation of Amacle 2 0 This neachon is used to fest for -N-R -E-DH H) N-R Caboxylic acid. the high styles in asters harpens 1. Aria Amrde Lobinio and formation of Acid amputricle 2 DH HO-E-R > R--0-E-A+H20 acid aniyday

Byntress Acid entries (Pregaration, op Geboxylic Acid Subolatic () Oxidation of primary alcohol and stand R-CEM R-2 03 R-COH EO] > R-E-H 15:00 otta- CN HARD CH3 COOH carboztik not ton aldelyte 100 y (11 0 ctt,ott -9 27th May, 2024 2-04 JONes -(a) R-C-0R' ##/120 HOR R-C-OH P This reaction occurs at equilibring which will not produce a good yearst Mala <-Superorder of Rooth At base is used instead of 2 aerd Hydrolysis of Carboxylic acid derivatives Calhoryble and derivatives; R- C-Opt NaOH (Has p- E-On a + ++= 0 Using weder to split ester hydrodysis -cojbit + amide. R-C-OR-R-2-01 = R-2-0-49 acid chloride . Ho. acid anydride -Nitrile ->R-E-ONA FHOR' 1 hours Examples Ester 0 80 H1/H20 -C+0-R' Ozondysis of Alkynes R-0-04- + Hor 3 -C=C Gronylic R-C-04 HS OH Ozonowa (A) amide 1100 + 40-5 R-CENH-R' HTTHE R-C-OH F HNH-R' 4) Graynard Reaction -CH_-OH -OH Cabo 2 gut amine HYOH RMgx €-0# a hydrolysis of esters happens faster than amides 10213 to notion of the GP

Cil Mg - a Feto-hexase -CH2CL Mg Doyetur 34-1 cth ot 20 CO2 player all shapes -40 CH3-C-0 H+ CH2-C-OH ot Cet 2 Ott 9-Fructose COLMANT Oxidation of benzenes with Alfy Subditition fisher -> halworn al muta rotato oo : COOH KM De CH2 OH Anomen CH3 EZCH3 CH3 Km2 .cool) COU C-O CH3 3 GH C-di X-D-gluoprands 4 C-OH cool Kmh 0400 Ct.z. (1) EB, depending 12-(An how off A#anomeric a CH20H 6 CA20U OOR Falle an arosil - 12. B-B- Plant & Anomenic reaction or hemiorotal reation Carbohy drater B-D-ghicopyranose Classification of carbohydrate can be 64% Lecause basedon functional group (aldenight and lettore) 36% d-D-glucoppranose effect which are aldoses or lectoses. CHO etto CH2 OH unfuno240 are. CHOth H-C-0H n -4 10 all will a 40-C-H Statt ermus HO-C-H H- -C- OH HUNNE Attre sonly on position a H-C-ott Ott H - C - OH -OT H-C-0H HSC -Ott Ct ott X-D-fructofuranose D- mannose D-glucose (also, aldo herose) 62 A20H 255 C CHO - DH H 3 1-0 D-galactosa H EttoH at.

1.0 CHEMISTRY OF CARBOHYDRATES (SECTION ONE)

This section gives a simple treatment of the Chemistry of Carbohydrates. It provides concise information on this class of Chemistry and suitable for beginners.

Carbohydrates are natural products with general a formula $Cn(H_2O)n$. Other names for carbohydrates are also saccharides. This very large family includes monomers - called simple sugars or monosaccharides up to very large molecules (complex) called polymers which are made up of these simple sugars. The polymers are also called polysaccharides such as starch, cellulose, dextrin and glycogen.

1.1 Classification and nomenclature of monosaccharide

1.1.1 *Monosaccharides*

Monosaccharides are chiral polyhydroxyalkanals or polyhydroxyalkanones which are the cylic hemiacetal forms of these sugars. This class of saccharide is divided into two major groups depending on whether their acyclic forms contain an aldehyde functional group or a keto functional group which are aldoses or ketoses, respectively.

Aldoses and Ketoses: All monosaccharides have their names end with *"ose"* hence, they are divided into aldoses that is aldehyde plus ose) and ketoses (<u>ketone plus ose</u>). For example, glucose is an, aldose while fructose is a ketose (Figures 1.0 a & b).



Figure 1.1 a & b: Structures of D-glucose and D-fructose

The above structures are the *Fischer projections* of these monosaccharides. The aldehyde functional group (carboxaldehyde carbon) of an aldose is assigned number 1 and the primary alcohol group (-CH₂OH) assigned the last number.

The simple sugars can also be classified according to the number of carbons that they contain. Both glucose and fructose given in Figure 1.1 a & b above contain six carbons each, hence they are both **hexoses**. If both classifications (functional groups and number of carbons) are combined, then glucose will become an **aldohexose** and fructose a **ketohexose**.

1.2 Glyceraldehyde and dihydroxyacetone

The simplest carbohydrates - glyceraldehyde and dihydroxyacetone, which are **aldotriose** and a **ketotriose**, respectively (Figure 1.2 a & b). All series of aldoses and ketoses are built from glyceraldehyde and dihydroxyacetone, respectively.


1.3 D - and L - Monosaccharides

Using Fischer projection, the first carbon is a carbonyl carbon for aldose and the second carbon is carbonyl for ketose. If the last **chiral carbon** has its hydroxyl group on the right, the sugar is designated **D** - **sugar** but if it is on the left, it is a **L** - **sugar**. See Figure 1.3.1 a & b below:



The Figure 1.3 a & b shows that L - Glucose is an enantiomer of D - Glucose.

The simplest sugar is glyceraldehyde ($C_3H_6O_3$). Because it contains three carbons, it is a triose, and it is an aldotriose because its first carbon is an alkanal.

Emil Fischer assigned the configuration (-) - glyceraldehyde to glyceraldehyde drawn using Fischer projection if the hydroxyl group of the only chiral carbon is on the left which called "L" (*laevo*). When the hydroxyl group is on the right of the chiral carbon, he called it "**D**" (*dextro*).

These two enantiomers of glyceraldehyde were later assigned "S" (*sinister*) for L - configuration and "R" (*recutum*) for D - configuration.

Any molecule that contains n chiral centres will have 2^n stereoisomers provided no meso compounds are present. For example, if there two chiral centres, hence $2^2 = 4$, which means four carbon sugars (aldotetrose). Their structures are given in Figure 1.3.2 a, b, c & d below:



Figure 1.3.2 a, b, c & d: Structure of the stereoisomers of aldotetrose

These four aldotetroses were obtained by inserting **-HCOH-** between carbonyl carbon and the next chiral carbon of both L - glyceraldehyde and D - glyceraldehyde and the mirror image of each will give the other two compounds to make four aldotetroses given above.

1.3 Epimers

An epimer is one of a pair of **diastereomers.** Epimer occurs when two molecules have different configuration at only one chiral centre. That is all other chiral centres in the molecule are the same except one chiral centre. Examples are D - Glucose and D - Mannose (Figure 1.4 a & b).



Figure 1.4 a & b: D-glucose and D-mannose

Diastereomer

This term is used to describe two molecules that are stereoisomers with the same formula, connectivity but different arrangement of atoms in space but are not enantiomers. That is the two molecules are not mirror images of each other or non-identical stereoisomers. They occur when two or more stereoisomers of compound for example sugar have different arrangement of atoms at one or more chiral centres but not at all centres which makes them not to be superimposable. If this different is at only one chiral centre, they are called *epimers*.

The simplest ketose, dihydroxyacetone (Figure 1.5) lacks a chiral centre. Insertion of **-CH(OH)**unit between the carbonyl carbon (carbon number 2) and the third carbon creates erythrulose (Figure 1.6). The D isomer of erythrulose is the bases of the D-ketose sugar series.





Figure 1.6: Formation of erythrulose from dihydroxyacetone

Ring structure of Monosaccharides

Glucose and other sugars can exist as cyclic hemiacetals or hemiketals. They are formed from intra-molecular reaction of a hydroxy group with a carboxyl group. Glucose and other aldohexoses form their most stable acetal by using the hydroxy group on carbon number 5, and the six-membered ring compound obtained is called the pyranose because it resembles tetrahydropyran (Figure 1.7). Hence, the cyclic form of D-glucose is called D-glucopyranose.



Figure 1.7: Terahydropyran from hydrogenation of γ-pyran

The hemiacetal formation or *anomeric reaction* creates a new chiral centre called *anomeric carbon or anomeric centre* that is carbon number one (Figure 1.8). This reaction results in two diastereomeric products that differed in configuration on the anomeric carbon. The two products are also called *Anomers*. These anomers are designated – α or - β depending upon the relative configuration of the anomeric carbon (Figure 1.9 a and b).



Figure 1.8: Anomeric reaction in D-Glucose (anomerization reaction)



Figure 1.9: The α -form and the β -form of the glucose in ring forms

The structures in the Figure 1.9 above resemble the hydrogenated γ -Pyran (Figure 1.7) above, hence, D-glucose in ring form is named after pyran that is α - or β - D – glucopyranose (Figure 1.10 a and b).



Figure 1.10 a & b: α- D – glucopyranose and β- D – glucopyranose

Ketohexoses also undergo the same intramolecular reaction described above for aldohexose using hydroxy on carbon number 5 (Figure 1.11). This anomeric reaction leads to the formation

of five membered ring compound named after tetrahydrofuran because it resemblances hydrogenated Furan (Figure 1.12). The reaction leads to the formation of two products which are also called *Anomers*. These anomers like glucopyranose are designated - α or - β depending upon the relative configuration of the anomeric carbon. The ring forms of D-Fructose resemble hydrogenated Furan (Figure 1.12), hence, the ring structure of D-Fructose is named after Furan that is α - or - β - D-Fructofuranose (Figure 1.13 a and b).



Figure 1.11: Anomeric reaction in D-Fructose (anomerization reaction)



Furan

Tetrahydrofuran





α - D-Fructofuranose (a) β – Fructofuranose (b)

Figure 1.13 a and b: α - or – β - D-Fructofuranose

The ratio of the α - D- glucopyranose to β - D- glucopyranose is 36 : 64% in nature. This is because the beta form is more stable than the alpha anomer. This stability can be explained using the *anomeric effect*.

This effect arises from the orbital interaction between oxygen (heteroatom) and the anomeric carbon that is the CO bond. This reaction occurs when the anomeric hydroxy is in the *axial position* (Figure 1.14) that is *a*-form but this destabilizing reaction is not possible with the OH group in the *equatorial position* (Figure 1.15) that is β -form.



Figure 1.14: Figure showing OH group drawn in the axial position



Figure 1.15: Figure showing OH group drawn in the equatorial position

Any ring substituents that are drawn perpendicularly to this axis of symmetry are called *equatorial* while those drawn parallel are referred to as *axial*. For example, the OH group and other substituents on the β - D - glucopyranose are perpendicular to this axis. This reduces steric

hindrance, hence, the β - form is more stable than the α - form. This is another explanation for the reason why β - and α - forms are 64 and 36 % in nature, respectively.

Deoxy and Amino Sugars

In nature, sugars can have one or more of their OH group(s) replaced by some substituents. Of these, substituents, H and $-NH_2$ are the most common. A Deoxy sugar has $-CH_2$ - group is place of a -CH(OH) - group. The most common deoxy sugar in nature is 2-deoxy—D—ribose (Figure 1.16) which is the sugar moiety of deoxyribonucleic acid (DNA).



2 - deoxy - D - ribose

Figure 1.16: 2-deoxy-D-ribose

Amino sugar on the other hand has $a - CH(NH_2) - group$ replacing a - CH (OH) - group. Examples of important amino sugars are D - galactosamine and D - glucosamine (Figure 1.17 a & b).



Figure 1.17 a & b: D-glucosamine and D-galactosamine

1.3 SOME REACTIONS OF MONOSACCARIDES

1.3.1 *Reduction to glucitols*

Aldose monosaccharides such as D-glucose can be reduced glycitols. For example, D-glucose can be reduced to D-glucitol (Sorbitol) using a reducing agent such as Sodium borohydride in water (NaBH₄/H₂O) (Figure 1.18).



1.3.2 Oxidation to gluconic acids

Aldoses are oxidized to glyconic acids using mild oxidants such as bromine water. For example, D-glucose is oxidized to D-gluconic acid (Figure 1.19).



Figure 1.19: Oxidation of D-glucosewith mild oxidant to D-gluconic acid

1.3.3 Oxidation to glucaric acids

The oxidation of aldoses to glucaric acids can only be carried out using strong oxidants such as HNO₃. If D-glucose is oxidized with strong oxidant, it will give D-glucaric acid (Figure 1.20).





1.3.4 (i) Reaction with Tollens' reagent

The Tollens' reagent is prepared according the chemical equations (1 & 2) given below:

This reaction is the popular mirror image test used for the confirmation of alkanal.

1.3.4 (ii) Reaction with Fehling's and Benedict's Solutions

Fehling's solution is made up of the following reagents: copper (II) ions complexed with tartrate ions. Both reagents are prepared in NaOH solution. On the other hand, Benedict's solution contains copper (II) ions with citrate ions instead of tartrate ions. It is prepared with Na₂CO₃ solution as against NaOH solution used for the Fehling's solution.

Both Fehling's and Benedict's solutions provide hydroxy ions that reacts with Cu^{2+} in complex form (equation 1). These hydroxy ions are provide by the NaOH and Na₂CO₃ used in the preparation Fehling's and Benedict's solutions, respectively. In the case of Benedict's solution, OH⁻ is obtained when CO₃²⁻ reversibly reacts with H₂O as follows:

$$CO_{3}^{2-} + H_{2}O \rightarrow HCO_{3}^{-} + OH^{-}$$

$$2Cu^{2+} + 2OH^{-} + 2e^{-} \rightarrow Cu_{2}O + H_{2}O$$

$$RCHO + 3OH^{-} \rightarrow RCOO^{-} + 2H_{2}O + 2e^{-}$$
(1)
(2)

(1) + (2) gives the overall chemical equation for the oxidation of the alkanal

$RCHO + 50H^- + 2Cu^{2+} \rightarrow RCOO^- + 3H_2O + Cu_2O \ (red \ ppt)$

Only reducing sugars (aldoses) like D-glucose can be positive to Tollens', Fehling's and Benedict's tests. But it was observed that Fructose, a non-reducing sugar gives positive Tollens' test. This was made possible because a base catalyzed equilibrium takes place between glucose, mannose and fructose. The alkaline nature of this reagent provides this base catalyst and the rearrangement is called *Lobry de Bruyn-Van Ekenstein rearrangement*. The mechanism for the conversation is given by the following chemical equations (Figure 1.21).



Figure 1.21: The base catalyzed equilibrium between glucose, mannose and fructose

1.3.5 Reaction with hydrogen cyanide (HCN)

Hydrogen cyanide reacts with reducing sugars the same way it reacts with alkanals (aldehydes) by attacking the carbonyl carbon to give a hydroxynitrile compound. An example of this reaction is given below (Figure 1.22):



Figure 1.22: Reaction of reducing sugar with Cyanide to form hydroxynitrile compound

It should be noted that hydrogen cyanide is extremely poisonous gas; hence, it is not used directly. The aldehyde / ketone is reacted with a solution of sodium or potassium salt of cyanide in water along with little sulphuric acid to give a solution with a pH of between 4 and 5.

The Mechanisms of the Reaction

The mechanism is through nucleophilic addition. The mechanism is given below (Figure 1.23):



Figure 1.23: Mechanism for the reaction of reducing sugar with Cyanide

A typical example of this reaction is the reaction of D-arabinose with the solution of sodium cyanide given below. The reaction is called *cyanohydrin*. This reaction is also used in

carbohydrate synthesis for increasing the chain length of a sugar by one carbon for example the mixture of D-glucose and D-mannose from D-arabonise (Figure 1.24).

$$\begin{array}{c} CN \\ CHO \\ HO-C \\ -H \\ H-C \\ -OH \\ H-C \\ -OH \\ CH_{2}OH \end{array} \xrightarrow{HO-C \\ NaHSO_{3}} \begin{array}{c} COH \\ HO-C \\ H-C \\ H-C \\ -OH \\ CH_{2}OH \end{array} \xrightarrow{HO-C \\ H-C \\ C-OH \\ CH_{2}OH \end{array} \xrightarrow{HO-C \\ H-C \\ C-OH \\ CH_{2}OH \end{array} \xrightarrow{HO-C \\ H-C \\ C+OH \\ CH_{2}OH \end{array}$$

Mixture of D-glucose and D-mannose depending on spartial arrangement on carbon 2

Figure 1.24: Synthesis of D-glucose and D-mannose from D-arabinose

1.3.6 Ruff Degradation

Ruff degradation is a method used for reducing the chain length of a carbohydrate by one carbon. In this method, the sugar to be shortened is first converted to gluconic acid using bromine water followed by decarboxylation (removal of CO_2) using ferric salt. Example is the conversion of Dglucose to D-arabinose (Figure 1.25)

Questions

- 1. Show using a suitable chemical equations how D-fructose forms hemiacetal.
- 2. Draw the structures of the following sugars: (a) D-ribose, (b) D-arabinose
 - (c) D-mannose and (d) D-galactose.



Figure: 1.25: Ruff degradation reaction for converting D-glucose to D-arabinose

1.3.7 Periodic acid oxidation

This is another method for determining the ring size of glycosides. It proceeds stoichiometrically and is a measure of the number of adjacent free hydroxyl groups. In this method, the moles of periodic acid (or sodium metaperiodate) consumed and the moles of formaldehyde and formic acid produced during the oxidation of a known weight of the saccharide under investigation are determined. One mole of the oxidant is reduced (consumed when two adjacent OH groups are oxidized with cleavage of the C-C bond joining them to yield two aldehyde groups. Terminal hydroxyl group yields formaldehyde while secondary hydroxyl group yields another aldehyde or form C acid if the 2⁰⁻ hydroxyl group is flanked on both sides by hydroxy groups (i.e. is oxidized twice). From the results, it is possible to determine the number and type $(1^0 \text{ or } z^0)$ of adjacent hydroxyl groups present in a molecule. The general reactions are given below (Figures 2.6 A to F)





Figure 2.6 C



Figure 2.6 D

 α - hydroxy aldehyde







Figure 2.6 F

When all the steps are added up glucose will produce five times as much methanoic acid as methanal.

This type of degradation has played a vital role in understanding the structures of many carbohydrates. The degradation of α -D-glucopyranose by periodic acid is given below (Figure 2.7).



Figure 2.7: The degradation of Alpha - D - glucopyranose by periodic acid

1.4 Disaccharides

According to the name, they all consist of two simple sugars held together by *a glycosidic bond*. Like monosaccharides, disaccharides are also simple sugars which are water soluble. Some typical examples of disaccharide are maltose, sucrose, lactose, cellobiose, getiobiose etc.

They have two simple sugars held together by a glycosidic bond. The most common involves the anomeric carbon of one sugar and non – anomeric carbon of the other (Compound Y)..



MALTOSE

 β – Maltose carries the impressive systematic name O – α – glucopyranosyl – (1,4) – β – D – glucopyranose. The disaccharide contains two latent carbonyl carbons. The one in the ring at the upper left is tied up in the glycosidic linkage. The other is in the ring at the lower right and is still a hemiacetal. The position of the free hemiacetal hydroxy group determines if it is β or α , which must appear in any name of the compound.

See the structure given in the class

Note, the structure of maltose is compound Y above.

Cellobiose and Gentiobiose

These are disaccharides that contains β – D glucopyranose bonded to a second β – D glucopyranose residue via a glycosidic bond. Cellobiose possesses a glycosidic bond between C1 and C4 of two simple sugars, while gentiobiose has a glycosidic between C1 and C6 of two simple sugars.





Figure 3.4: β - D - glucopyranosyl-1, β - D - glucopyranose(β - Cellobiose)

Figure 3.5: β - D - glucopyranosyl-1 β - D - glucopyranose(β - Gentiobiose)

SUCROSE

The alternative names of sucrose are cane sugar or beet sugar. It is the common table sugar, $o - \alpha - D$ – glucopyranosyl – (1,2) – β – D – fructofuranoside. This sugar is different from other disaccharides, thus, far studied because its glycoside linkage involves the anomeric centre of both sugars.



Sucrose, unlike maltose, Lactose, Cellobiose, and gentiobiose, doesn't exist as readily – inter – converted α and β – forms.

The fructose position of the name ends in "oside" in order to indicate that C2 of fructose is involved in the glycoside bond,

Because both anomeric carbons are involved in acetal formation, sucrose is a non-reducing sugar. It is negative to Tollen's reagent and Fehling's solution or Benedict's solution. Moreover, sucrose does not form an osazone, does not exist on anomeric forms and does not show mutarotation in solution. All these facts indicate that sucrose does not contain a "free" aldehyde or ketone group. When sucrose is hydrolysed by dilute aqueous acid or enzyme invertase (from yeast), equal amounts of α – D glucopyranose and β - D – fructofuranose are produced.

POLYSACCHARIDES

Polysaccharides are polymers containing as many as several thousands monosaccharide unit per molecule. As with other saccharides, it is important to know the following:

- (a) Which specific monomer are involved in the polymer formation
- (b) The method of linkage between the monomer
- (c) The gross structure of the polymer.

If the polymer contains more than one type of monosaccharides, then the sequence of the sugars is also important.

Of all the naturally occurring polysaccharides, starch and cellulose are the most important. Both are products of photosynthesis. Cellulose play a tremendous role in our society. As wood, cellulose provides shelter, as pulp, it is the major constituent of cotton which is a natural fibre. Starch is the mainstay of many diets since it is the major compound in rice, potatoes, wheat and corn.

<u>STARCH</u>

This is the major source of energy in plant cells. When intact, starch granules are insoluble in cold water; if the outer membrane has been broken by grinding, the granules swell in cold water and for a gel. When the intact granule is treated with warm water, a soluble portion of the starch diffuse through the granule wall, in hot water the granules swell and then burst Starch contains two major fractions: amylose ($\approx 20\%$) and amylopectin ($\approx 80\%$). Both can be hydrolysed in acidic medium to give on D – glucose, since both polymer contains the same monomer, the important differences between them must exist in the bonding within these polymers.

AMYLOSE

Maltose is the only disaccharide produced upon hydrolysis of amylose. The absence of cellobiose suggests that amylose is a linear polymer of D – glucose molecule, each bonded by an α – glycosidic linkage to C 4 of the adjacent glucose unit. If cellobiose had been produced, the β – glycosidic linkage would have been produced.

Amylose then is believed to be made up of long chains, each containing 1000 or more $\alpha - D$ glucopyranose units joined together by α – linkage as in maltose.



 α – Amylose is the fraction of starch that gives the intense blue colour with iodine. X – ray analysis shows that the chain coiled in the form of helix (spiral staircase) inside which is just enough to accommodate iodine molecule; the blue colour is due to entrapped iodine molecules.



AMYLOPECTIN

Amylopectin is a branched polymer containing about 1000 D – glucose units. The main chain consists of an α – 1, 4 – D glycosidic linkage while branching occurs with an α – 1, 6 – D glycosidic bond. Branching is moderate with perhaps twenty five α – D glucopyranose units occurring between branching points.

The partial hydrolysis of amylopectin produces large molecules called dextrins. Dextrins are used to prepare mucilage, pastes and fabric sizing. (sizes are materials used to fill pores in cloth, paper; etc.). printing inks is often thickened by the addition of dextrins.

The major disaccharide produced by the hydrolysis of amylopectin is maltose, the glucose unit at each point has C - 1 and C - 6 - OH groups involved in glycosidic linkages. This leads to small amount of isomaltose upon hydrolysis.



Structure of amylopectin

Amylopectin is hydrolysed to a single disaccharide maltose; the sequence of methylation and hydrolysis yields chiefly 2,3,6 – tri – o – methyl – D – glucose. Like amylose, amylopectin is made up of chains of α – D glucopyranose units, each unit joined by alpha – glucosidic linkage to C – 4 of the next one. However, its structure is more complex than that of amylose.



CELLULOSE

Cellulose is an unbranched polymer of β – D – glucose which occurs in most plants. Most animals, including man and cattle, cannot hydrolyse the β – glycosidic link in cellulose

Cotton which is the most important natural fibre, is about 98% cellulose. Acetal linkage in cellulose are hydrolysed by acids but not by bases.



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PROTEIN STRUCTURES

Protein primary structure is the linear sequence of amino acids in a peptide or protein. By convention, the primary structure of a protein is reported starting from the amino-terminal (N) end to the carboxyl-terminal (C) end. Protein biosynthesis is most commonly performed by ribosomes in cells. Peptides can also be synthesized in the laboratory.

Isomerisation

The chiral centers of a polypeptide chain can undergo racemization. Although it does not change the sequence, it does affect the chemical properties of the sequence. In particular, the L-amino acids normally found in proteins can spontaneously isomerize at the atom to form D-amino acids, which cannot be cleaved by most proteases. Additionally, proline can form stable transisomers at the peptide bond.

Secondary structure



An α -helix with hydrogen bonds (yellow dots)

Secondary structure refers to highly regular local sub-structures on the actual polypeptide backbone chain. Two main types of secondary structure, the α -helix and the β -strand or β -sheets, were suggested in 1951 by Linus Pauling. These secondary structures are defined by patterns of hydrogen bonds between the main-chain peptide groups.

Secondary structure of protein refers to local folded structures that form within a polypeptide due to interactions between atoms of the backbone.

• The proteins do not exist in just simple chains of polypeptides.

- These polypeptide chains usually fold due to the interaction between the amine and carboxyl group of the peptide link.
- The structure refers to the shape in which a long polypeptide chain can exist.
- They are found to exist in two different types of structures α helix and β pleated sheet structures.
- This structure arises due to the regular folding of the backbone of the polypeptide chain due to hydrogen bonding between -CO group and -NH groups of the peptide bond.
- However, segments of the protein chain may acquire their own local fold, which is much simpler and usually takes the shape of a spiral an extended shape or a loop. These local folds are termed secondary elements and form the proteins secondary structure.





Three-dimensional structure of parts of a beta sheet in green fluorescent protein

Tertiary Structure of Protein

- This structure arises from further folding of the secondary structure of the protein.
- H-bonds, electrostatic forces, disulphide linkages, and Vander Waals forces stabilize this structure.
- The tertiary structure of proteins represents overall folding of the polypeptide chains, further folding of the secondary structure.
- It gives rise to two major molecular shapes called fibrous and globular.
- The main forces which stabilize the secondary and tertiary structures of proteins are hydrogen bonds, disulphide linkages, van der Waals and electrostatic forces of attraction.

The three-dimensional arrangement of all the atoms of a single polypeptide chain in space, held together by stabilizing interactions between groups on the side chains and between the side chain groups and the backbone groups is called the **tertiary structure of proteins**.

The stabilizing interactions involved in stabilizing the tertiary structure include disulfide linkage, salt bridge, coordinate bonds with metal ions, hydrogen bonding, and hydrophobic interaction, as shown in Fig. and explained below.



This figure illustration of disulfide linkage, salt bridge, coordinate bonds with metal ions, hydrogen bonding, and hydrophobic interaction that stabilize the tertiary structure of proteins.

Chemical reactions and interactions of Amino acids and proteins

Reactions of various functional groups of amino acids and proteins are used for the chemical estimations.

(i) Reaction with ninhydrin(2,2,-D, hydroxyl-13-indasdione

The reaction leads to the formation of coloured complex which is used for quantitative determination of amino acids.



(ii) Reaction with 1,2- Benzene dicarbonal: 1,2- Benzene dicarbonal reacts with amino acids to give highly fluorescent isoindole derivatives.



1, 2 - Benzenedicarbonal or O-phtaldialdehyde

(iii) Reaction with phenylisothiocyanate



(iv) Reaction with Dansyl chloride (1, 1-Dimethy-aminonaphthalene-5-sulfonyl chloride)



The following reactions are used for the N-terminal analysis of proteins:

A. Sanger's reagent, FDNB (fluorodinitrobenzene), modifies N-terminus for determination via amino acid analysis.

