Alkenes

WHAT ARE THEY?

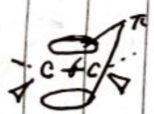
- unsaturated hydrocarbons
  - ↳ at LEAST one C=C double bond.
- C_nH_{2n} (same as cycloalkane)
- double bond is main group
  - ↳ must be in lowest sequence
- physical properties same as alkanes.

ISOMERISM

- Structural (branch, positional, func. grp)
- Stereoisomerism (only geometrical)
  - ↳ because of restricted rotation about C=C double bond.

CHEMICAL PROPERTIES

- Spacial arrangement around C=C is planar
- bond angles = 120°
- sp^2 hybridisation,



- main reaction → ELECTROPHILIC ADDITION.
- electrophiles attracted to e^- rich C=C.

WHY ALKENES MORE REACTIVE?

- due to π bonds
- σ-bonds = direct overlapping of p orbitals
- π-bonds only side by side
- ∴ π-bond easier to break ∵ e^- density further away from nucleus.
- During reaction,
  - → break one π, form 2 σ
  - → π energy < σ energy
  - ∴ energy produced can compensate

ADDITION OF HYDROGEN

- Reagent = H_2 (g)
- Ni catalyst, 150°C

ADDITION OF BROMINE (TEST)

- Reagent = Bromine (l)
- Room temperature, bromine dissolved in hexane.
- red brown solution decolourised
  - * brown ⇒ only for iodine

OR

- bromine (aq) (bromine water)
- room temp.
- red brown → colourless.

COMBUSTION OF ALKENES

- flame = smoky ∵ unburnt carbon (soot) formed
- more soot than alkanes ∵ ↑ C : H ratio.

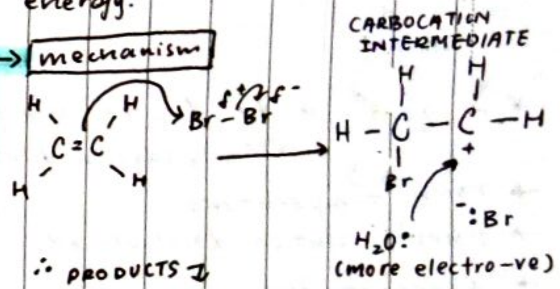
ADDITION REACTIONS

- 2 molecules react together to form a single product
- Addition of :
  - → Hydrogen (hydrogenation)
  - → Bromine (test for alkenes)
  - → Steam
  - → Hydrogen halides.

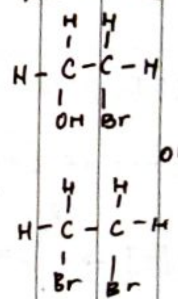
ADDITION OF STEAM

- to make alcohols.
- Reagent : H_2O (g) (steam)
- 330°C, 6 MPa, catalyst = conc H_3PO_4
- needs heating because O–H bonds are stronger ∴ need more energy.

mechanism



∴ PRODUCTS ↓



① + HBr (major)

or

② (minor)

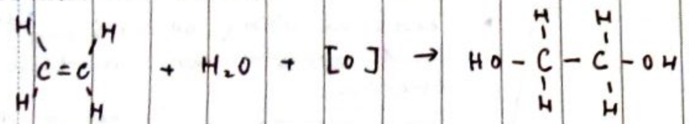
ADDITION OF HYDROGEN HALIDES

- reagent = HBr (g)
- mix gases at room temp (H–Br ↑ easier to break)
- In asymmetrical alkenes,
  - * major, minor product,
  - in question, write major product.

POLYALKENES

- Addition reaction
- Eg. poly(ethene) → plastic bags
  - poly(chloroethene)/PVC → pipes, electrical insulator
  - poly(tetrafluoroethene) → 'non-stick' coatings (C–F stable)
- fairly inert, resistant to chemical attack, non-biodegradable
- landfill problem, recycling high cost cuz collecting / reprocessing, separation
- toxic fumes when burnt, remove by 'scrubbing'
- waste convert to useful hydrocarbons.

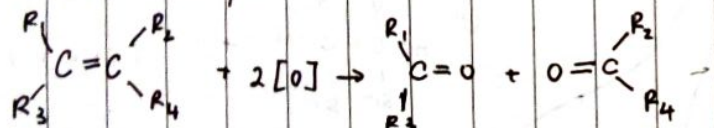
OXIDATION OF ALKENES

- **COLD, DILUTE** acidified potassium permanganate (VII)
- cannot use dichromate cuz too weak.
- 

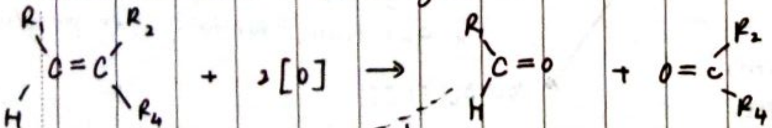
  ethene → ethane-1,2-diol (only add 2 -OH)

  $C_2H_4 + H_2O + [O] \rightarrow HO-CH_2-CH_2-OH$
- Reagent : acidified potassium permanganate (VII) / $KMnO_4$ (aq) in dilute H_2SO_4 (aq)
- room temperature
- purple solution decolourised.
- alkene → diol

"hydration"

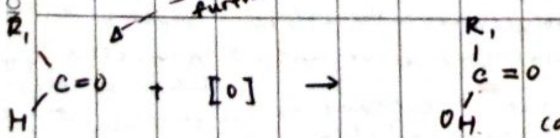
- **HOT, CONCENTRATED** potassium permanganate (VII) solution
- to determine position of C=C
- 

  break C=C, add back O
- reagent : concentrated acidified potassium permanganate (VII) solution
- conditions : hot
- observation : purple solution decolourised.
- if one R is H, then aldehyde ($-\overset{O}{\overset{\|}{C}}-H$) formed, will be further oxidised to carboxylic acid.



aldehyde — ketone ($-C-\overset{O}{\overset{\|}{C}}-C-$)

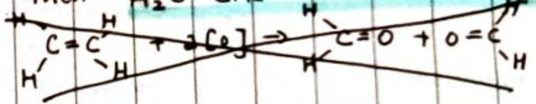
further oxidised

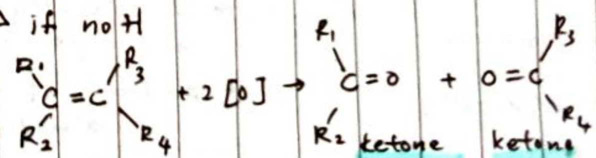


carboxylic acid.

Alkenes

- if all R is H, then $H_2C=CH_2 + 6[O] \rightarrow CO_2 + CO_2 + H_2O$

  
- if 2H, $RHC=CHR + 2[O] \rightarrow RCHO + RCHO \rightarrow RCOOH + RCOOH$
- if no H

  ketone ketone — no further oxidation.

REACTION MECHANISM IN ALKENES (ELECTROPHILIC ADDITION)

- Br_2 comes towards C=C, e^- in double bond repels e^- in nearest bromine in bromine molecule.
- polarises bromine molecule, nearest δ^+, further δ^-
- $Br^{\delta+}$ behaves as electrophile, forms single bond w/ π electrons from C=C
- Br–Br bond breaks heterolytically.
- carbocation intermediate & Bromide ion formed
- e^- from bromide ion react w/ unstable carbocation intermediate to form single bond.