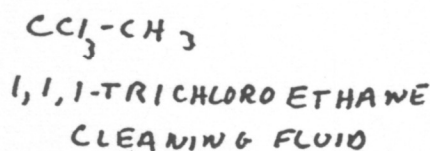
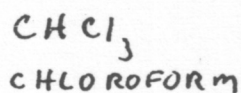
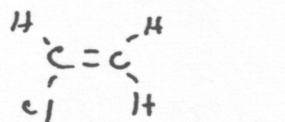


LECTURE NOTES FOR ORGANIC CHEMISTRY © MM2011
 ALKYL HALIDES AND NUCLEOPHILIC SUBSTITUTION AND ELIMINATION

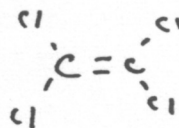
ALKYL HALIDE - HALOGEN BOUND TO AN sp^3 CARBON



VINYL HALIDE - HALOGEN BOUND TO AN sp^2 CARBON



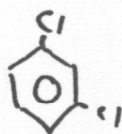
VINYL CHLORIDE
 MONOMER
 FOR PVC



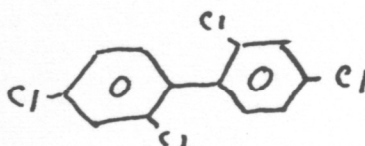
TETRACHLOROETHYLENE
 DEGREASER

ARYL HALIDES

HALOGEN BOUND TO AN AROMATIC sp^2 CARBON



O-DICHLOROBENZENE



1,3,1',3' TETRA
 CHLOROBIPHENYL

ONE OF 207
 PCB
 CONGENERS

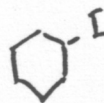
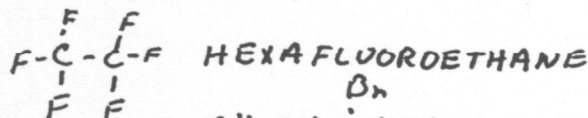
NOMENCLATURE

IUPAC NAMES USE

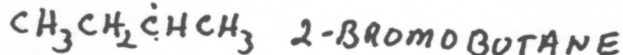
CHLORO
 FLUORO
 BROMO
 IODO



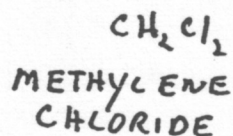
CHLOROBENZENE



IODOCYCLOHEXANE



SOME SMALLER HALIDES HAVE COMMON NAMES

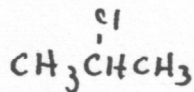


CHLOROFORM CARBON
 TETRACHLORIDE

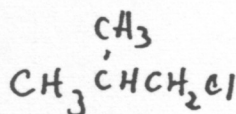
COMMON NAMES USE THE NAME OF THE ALKYL GROUP + HALIDE



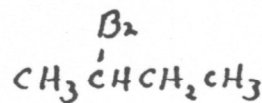
PLUS THE USUAL ISO AND SEC AND TERT



ISOPROPYL CHLORIDE



ISOBUTYL CHLORIDE



SEC-BUTYL BROMIDE

USES OF ALKYL HALIDES

AS SOLVENTS THEY ARE EVERYWHERE

CLEANERS, DEGREASERS, TO DECAFFEINATE COFFEE BEANS

HOWEVER, MOST OF THESE MOLECULES ARE TOXIC, SOME ARE CARCINOGENIC

AS REAGENTS

USED IN NUCLEOPHILIC SUBSTITUTIONS TO MAKE NEW BONDS

AS ANESTHETICS

CHCl_3 IS THE ORIGINAL (1850)

WE STILL USE HALOTHANE CF_3CHClBr

THE FREONS

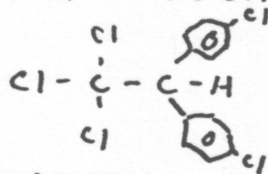
REFRIGERANTS AND "FOAMING AGENTS" IN PLASTICS, PROPELLENTS

CF_2Cl_2 FREON 12

KNOWN TO DAMAGE THE ATMOSPHERE BY REMOVING OZONE, O_3

AS PESTICIDES

DDT DICHLORODIPHENYL TRICHLOROETHANE



STRUCTURE OF ALKYL HALIDES

THE C-X BOND IS POLAR

C-I	C-Br	C-F	C-Cl
1.290	1.480	1.510	1.560

BOILING POINTS

BOTH POLAR AND LONDON FORCES OPERATE

GENERALLY INCREASE WITH MOLECULAR WEIGHT

DENSITY

OF FLUORIDES IS LESS THAN H_2O

MOST OTHER HALIDES ARE MORE DENSE THAN WATER

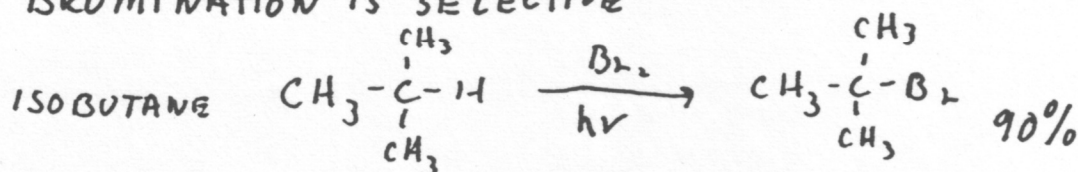
BUT MANY ALKYL CHLORIDES WITH 1 CHLORINE ARE LESS DENSE THAN H_2O

PREPARATION OF ALKYL HALIDES

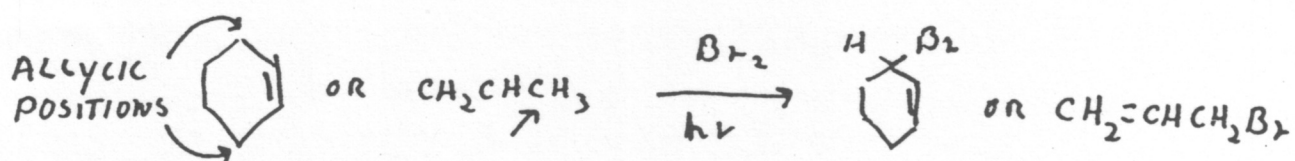
FREE RADICAL HALOGENATION

CHLORINATION USUALLY GIVES MIXTURES OF PRODUCTS

BROMINATION IS SELECTIVE



ALLYLIC HALOGENATION



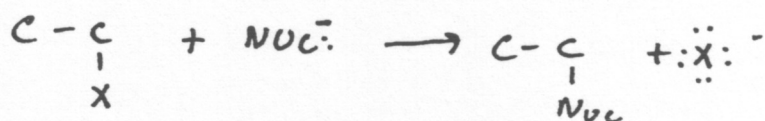
ALLYLIC INTERMEDIATES ARE RESONANCE STABILIZED
IN THIS CASES A RADICAL



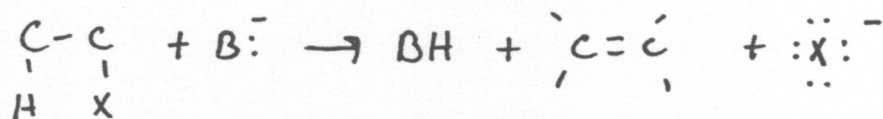
REACTIONS

NUCLEOPHILIC SUBSTITUTION AND ELIMINATION

ALKYL HALIDES UNDERGO SUBSTITUTION

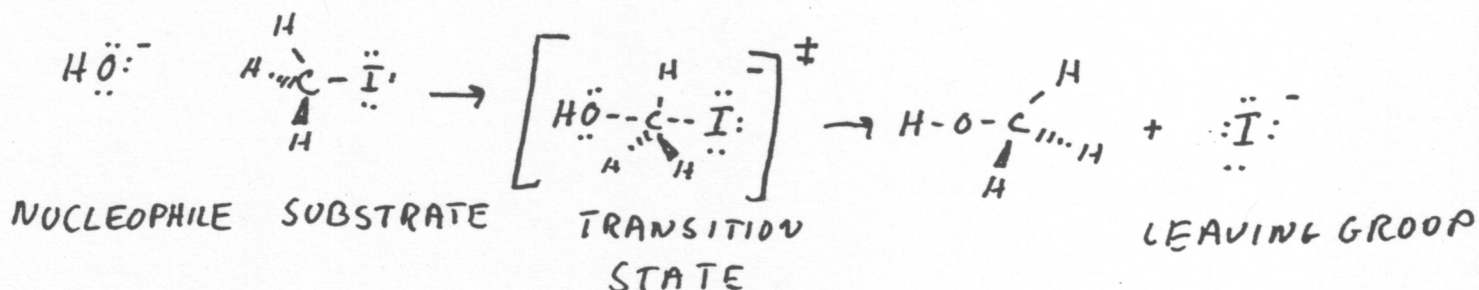
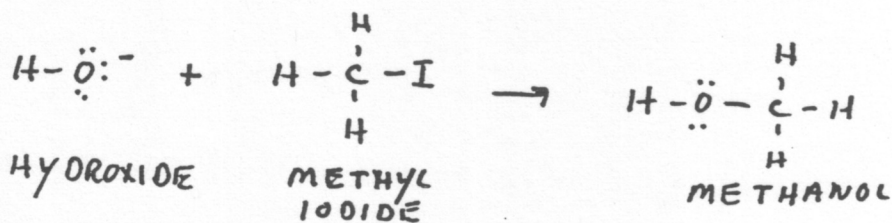
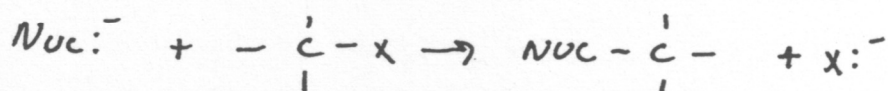


OR ELIMINATION

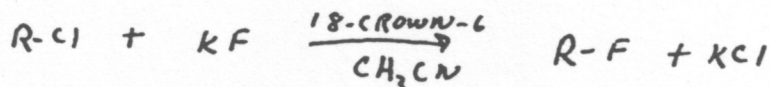


NUCLEOPHILIC SUBSTITUTION

THE SINGLE MOST USEFUL SYNTHETIC ORGANIC REACTION

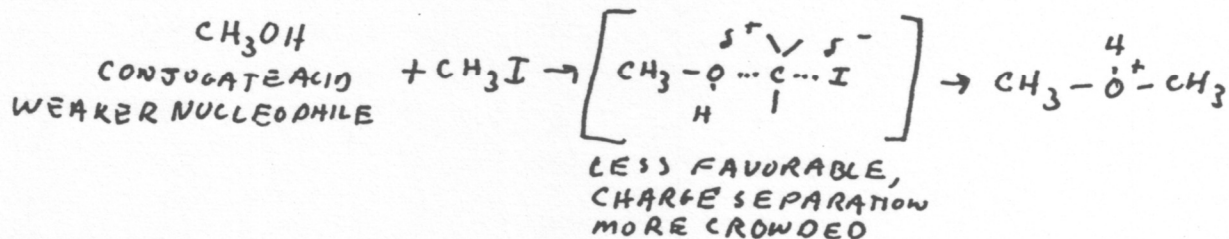
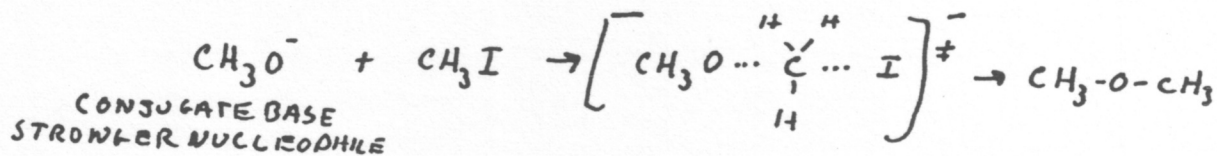


THE S_N2 REACTION, THATS SUBSTITUTION, NUCLEOPHILIC, BIMOLECULAR
 ITS USEFUL FOR CONVERTING ALKYL HALIDES TO A WIDE
 VARIETY OF DERIVATIVES SEE TABLE SUMMARY PG 241
 FLUORIDES AND IODIDES ARE MADE THIS WAY



FACTORS AFFECTING S_N2 REACTIONS 1) NUCLEOPHILE, 2) SUBSTRATE, 3) SOLVENT
 STRENGTH OF NUCLEOPHILE

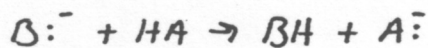
STRONG NUCLEOPHILES ARE DEFINED AS THOSE THAT RAPIDLY ATTACK ELECTROPHILE
 IN GENERAL, A NEGATIVE CHARGE IMPLIES NUCLEOPHILICITY
 AND A BASE IS ALWAYS A BETTER NUCLEOPHILE THAN ITS CONJUGATE ACID
 SO METHOXIDE IS A BETTER NUCLEOPHILE THAN METHANOL



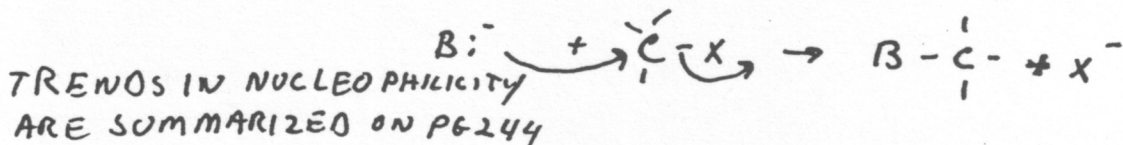
REMEMBER

BASICITY AND NUCLEOPHILICITY ARE DIFFERENT

BASICITY MEANS K_b IS LARGE



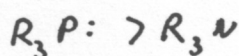
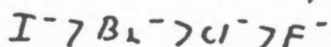
NUCLEOPHILICITY MEANS ELECTROPHILES ARE RAPIDLY ATTACKED



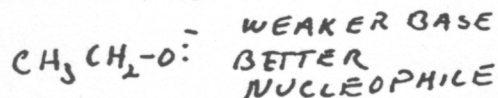
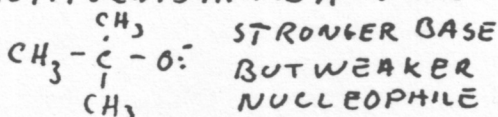
1) CONJUGATE BASE > CONJUGATE ACID $\rightarrow \text{OH}^- > \text{H}_2\text{O}, \text{NH}_2^- > \text{NH}_3$

2) NUCLEOPHILICITY DECREASES FROM LEFT TO RIGHT IN THE PERIODIC TABLE
 BECAUSE THE MORE ELECTRONEGATIVE ATOMS HOLD ELECTRONS MORE TIGHTLY
 $\text{OH}^- > \text{F}^-, \text{NH}_3 > \text{H}_2\text{O}, \text{R}_3\text{P}^- > \text{R}_2\text{S}^-$

3) NUCLEOPHILICITY INCREASES DOWN A COLUMN IN THE PERIODIC TABLE AS
 SIZE AND POLARIZABILITY INCREASE



4) TRULY BULKY SUBSTITUENTS MAKE A COMPOUND LESS NUCLEOPHILIC



S_N1 - THE LEAVING GROUP
 REALLY THE SAME AS FOR S_N2

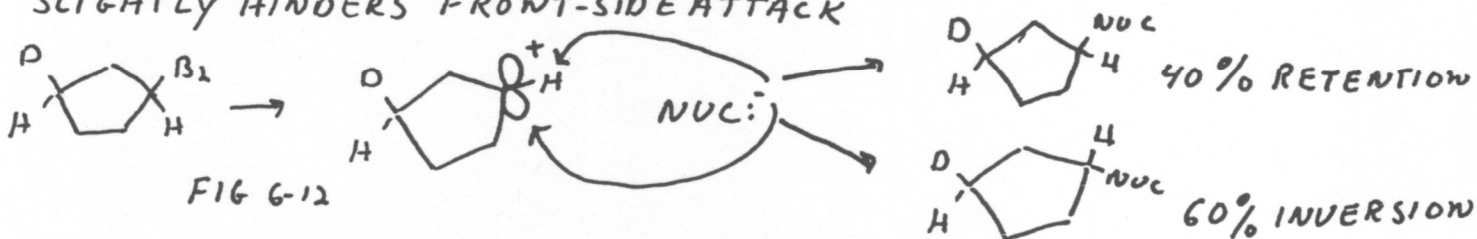
SOLVENT EFFECTS

- A POLAR SOLVENT STABILIZES CATIONS

- TABLE 6-6 SHOWS THE EFFECT OF SOLVENT POLARITY ON REACTION RATE

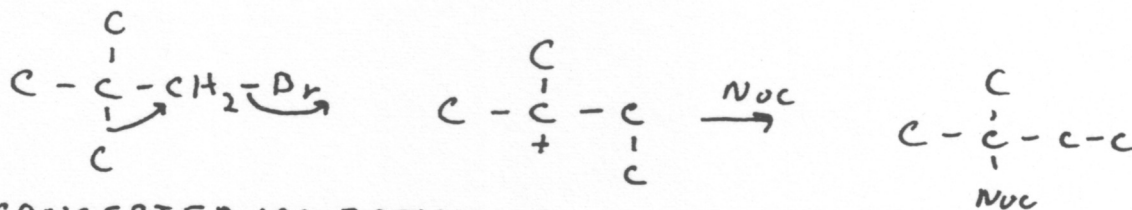
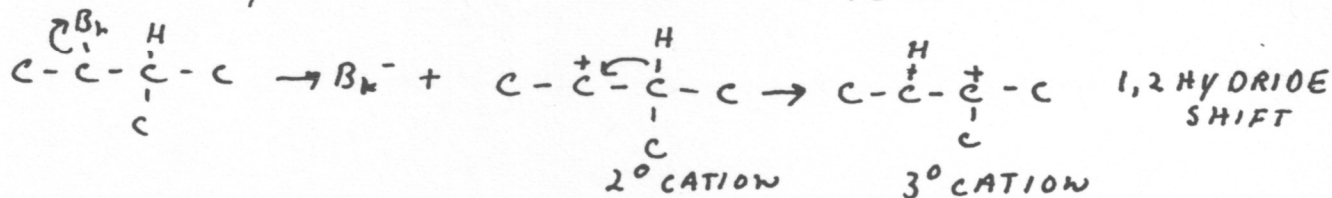
STEREOCHEMISTRY OF THE S_N1 REACTION

RACEMIZATION OF THE TRIGONAL PLANAR CARBOCATION
 ITS NOT ALWAYS COMPLETE AS THE LEAVING GROUP
 SLIGHTLY HINDERS FRONT-SIDE ATTACK



REARRANGEMENTS IN S_N1 REACTIONS

CARBOCATIONS MAY REARRANGE TO FORM MORE STABLE ONES



A CONCERTED IONIZATION

AND A 1,2 METHYL SHIFT

COMPARISON OF S_N2 WITH S_N1 TABLE PG 262

SUMMARY: Nucleophilic Substitutions

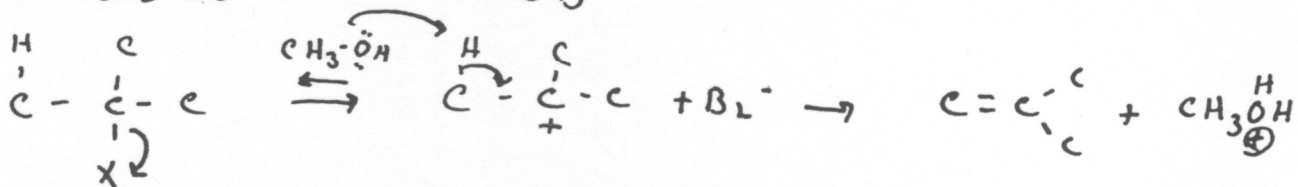
	S_N1	S_N2
promoting factors		
nucleophile	weak nucleophiles are OK	strong nucleophile needed
substrate (RX)	$3^\circ > 2^\circ$	$CH_3X > 1^\circ > 2^\circ$
solvent	good ionizing solvent needed	wide variety of solvents
leaving group	good one required	good one required
other	$AgNO_3$ forces ionization	
characteristics		
kinetics	first order, $k_f[RX]$	second order, $k_f[RX][Nuc]$
stereochemistry	mixture of inversion and retention	complete inversion
rearrangements	common	not possible

ELIMINATION REACTIONS

THE E1 REACTION

TWO ATOMS OR GROUPS ARE LOST FROM THE SUBSTRATE

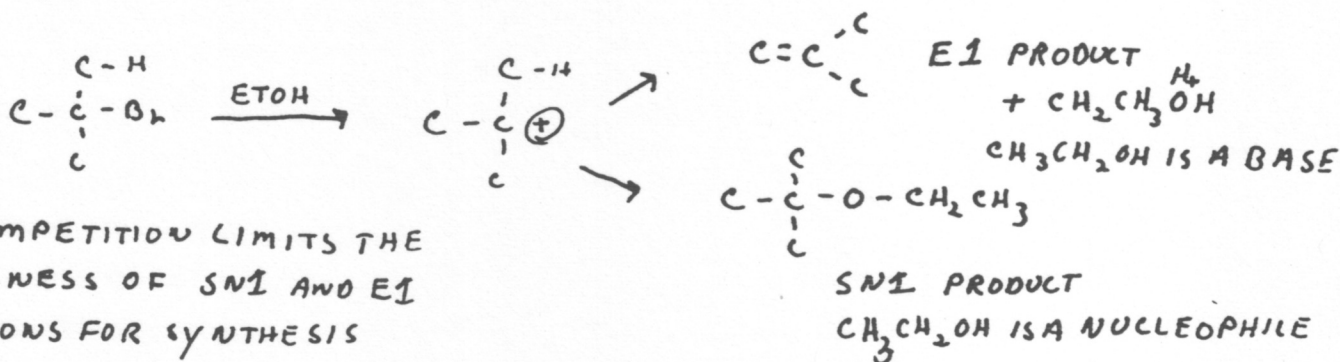
AND A DOUBLE BOND IS FORMED



THE FORMATION OF THE CARBOCATION IS RATE DETERMINING

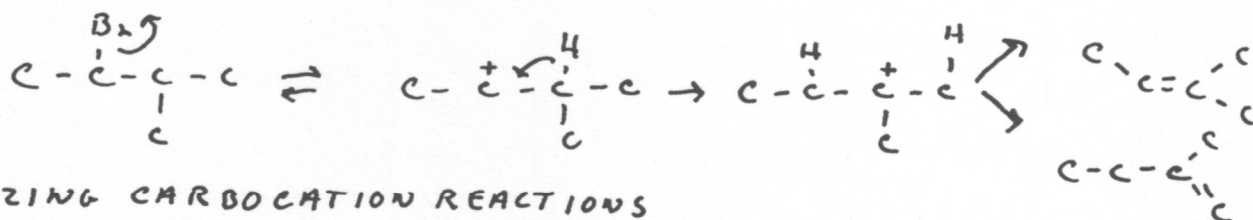
IN A SECOND, FAST STEP, A BASE ABSTRACTS A PROTON. THE ELECTRONS FROM THE FORMER C-H BOND FORM A π BOND, C=C

COMPETITION



THIS COMPETITION LIMITS THE USEFULNESS OF SN1 AND E1 REACTIONS FOR SYNTHESIS

THIS REACTION MAY BE SUBJECT TO REARRANGEMENT:

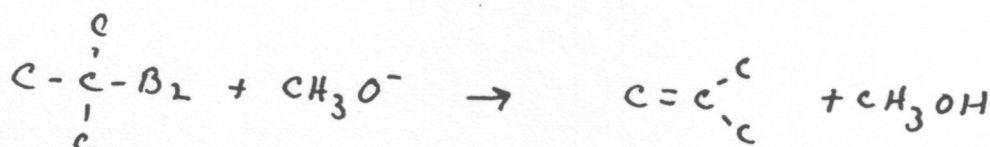


SUMMARIZING CARBOCATION REACTIONS

- 1) REACT WITH NUCLEOPHILE \rightarrow SUBSTITUTION SN1
 - 2) LOSE A PROTON TO FORM AN ALKENE E1
 - 3) REARRANGE TO A MORE STABLE ION, THEN FURTHER REACT
- STABILITY = RESONANCE STABILIZED $>$ $3^\circ >$ $2^\circ >$ 1°

SECOND-ORDER ELIMINATION: THE E2 REACTION

A STRONG BASE, SUCH AS METHOXIDE, CH_3O^- AND A HINDERED SUBSTRATE LEAD TO AN E2 ELIMINATION



TOO HINDERED FOR SN2

2nd ORDER, RATE = $k[\text{BASE}][\text{R-X}]$
 1 STEP, BIMOLECULAR, E2

E1 VS E2

ELIMINATION VS SUBSTITUTION

THERE IS ALWAYS COMPETITION BETWEEN THE 2

USE THESE GUIDELINES

- 1) THE STRENGTH OF THE BASE OR NUCLEOPHILE DETERMINES THE ORDER OF THE REACTION. A STRONG BASE OR NUCLEOPHILE FORCES E2 OR S_N2 BY ATTACKING BEFORE IONIZATION CAN OCCUR.
NO STRONG BASE OR NUCLEOPHILE → PROBABLY S_N1 OR E1
ADDITION OF A_g⁺ CAN FORCE IONIZATION
- 2) 1° HALIDES USUALLY S_N2
WITH STRONG BASE PRESENT E2 POSSIBLE
IF THE 1° CATION CAN REARRANGE, POSSIBLY S_N1, E1 REARRANGED PRODUCT.
- 3) 3° HALIDES USUALLY E2 (STRONG BASE)
NO STRONG BASE, S_N1 + E1 PRODUCTS
- 4) 2° HALIDES STRONG BASE E2 OR S_N2
NO STRONG BASE, S_N1 OR E1
MIXTURES ARE LIKELY
- 5) HIGH TEMPERATURES FAVOR ELIMINATION (-TDS)
- 6) BULKY STRONG BASES → ELIMINATION
GOOD NUCLEOPHILES WITH LIMITED BASICITY → SUBSTITUTION (Br⁻, I⁻)