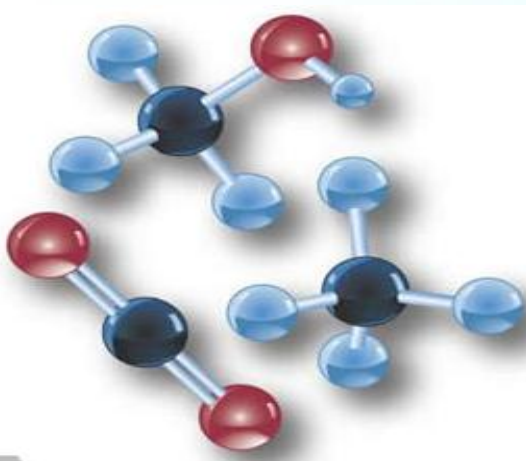




Organic Chemistry





Chapter 8

Organic Compounds

——Alkyl Halide



Outline:

1. How are haloalkanes named?
2. What are the characteristic reactions of haloalkanes?
3. What are the products of nucleophilic aliphatic substitution reactions?
4. What are the S_N2 and S_N1 mechanisms for nucleophilic substitution?
5. What determines whether S_N1 or S_N2 predominates?
6. How can S_N1 and S_N2 be predicted based on experimental conditions?
7. What are the products of β -Elimination?
8. What are the E1 and E2 mechanisms for β -Elimination?
9. When do nucleophilic substitution and β -Elimination compete?

IUPAC names for haloalkanes are derived by naming the parent alkane.

- ✓ Locate and number the parent chain from the direction that gives the substituent encountered first the lower number.
- ✓ Show halogen substituents by the prefixes fluoro-bromo-, and iodo-, and list them in alphabetical order along with other substituents.
- ✓ Use a number preceding the name of the halogen to locate each halogen on the parent chain.
- ✓ In haloalkenes, the location of the double bond determines the numbering of the parent hydrocarbon.



卤烃 $R-X$ ($X = F, Cl, Br, I$)

$R-Cl, R-Br, R-I$

性质接近
通常总称卤代烷

$R-F$

性质特殊
氟代烷

卤代烷的分类

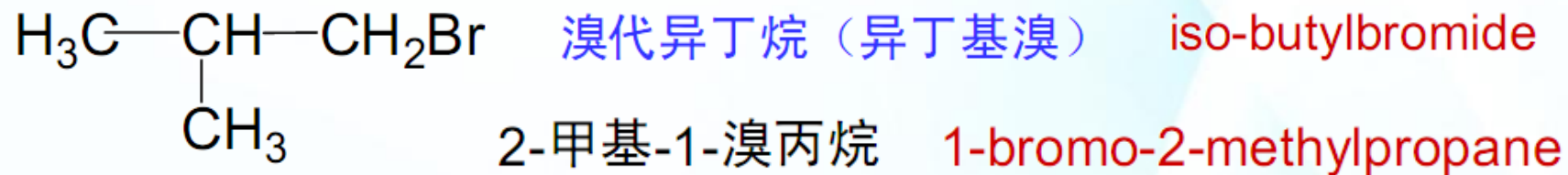
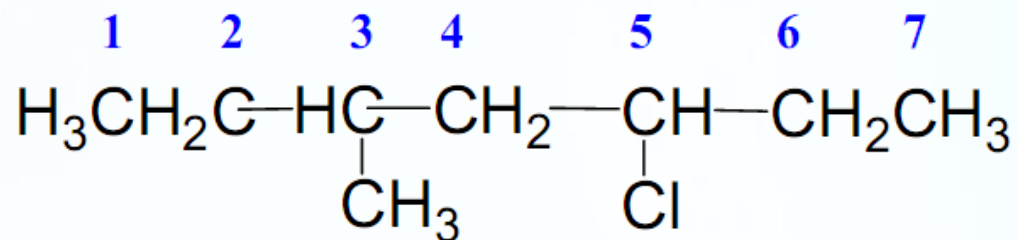
卤素的种类分为氟代烷、氯代烷、溴代烷和碘代烷

卤素的多少分为一元、二元和多元卤代烷

碳原子的类型分为伯、仲、叔卤代烷



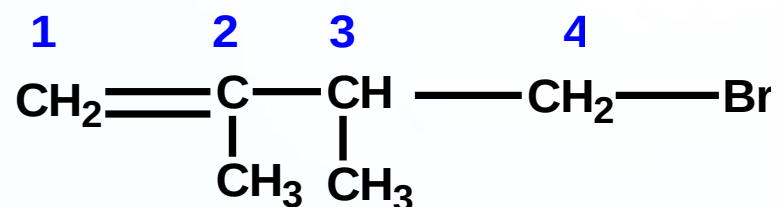
- 选取含卤素最长的碳链为主链，将卤原子作为取代基，取代基的位次相同时，小基团先编号，大基团后编号



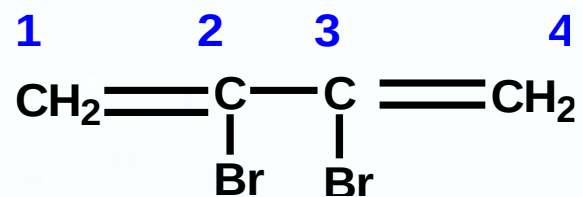
3-甲基-5-氯庚烷 5-chloro-3-methylheptane



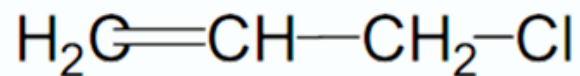
➤ 不饱和卤代烃命名时，选取含卤素和不饱和键最长的碳链为主链，把不饱和烃作为母体，尽量使双键或三键的编号最小



2,3-二甲基-4-溴丁-1-烯



2,3-二溴丁-1, 3-二烯

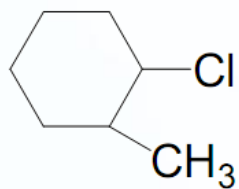


3-氯丙烯

3-chloropropene

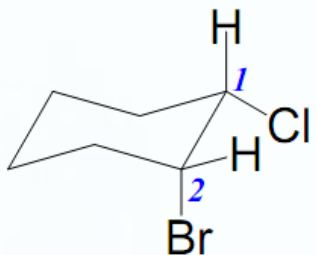


- 脂环烃和芳烃的卤代物命名时，把卤原子作为取代基，按照卤原子在环上的位次来命名



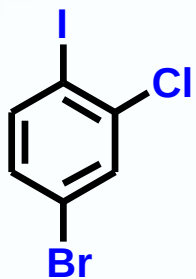
1-甲基-2-氯环己烷

2-chloro-1-methylcyclohexane



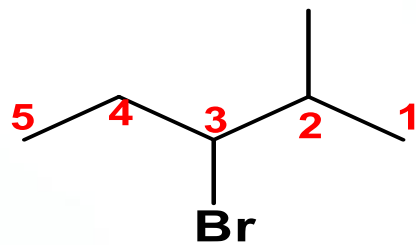
(1S,2R)-1-氯-2-溴环己烷

(1S,2R)-2-bromo-1-chlorocyclohexane

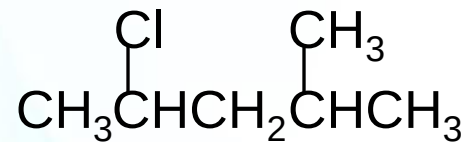


2-氯-4-溴-1-碘苯

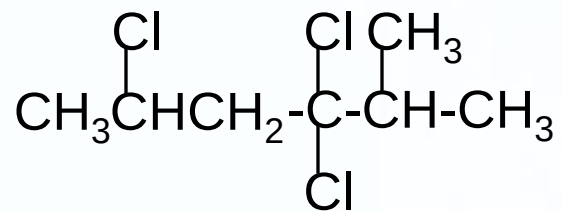
4-Bromo-2-chloro-1-iodo-benzene



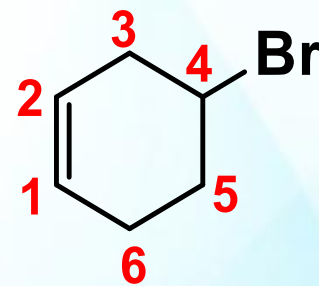
3-Bromo-2-methylpentane



2-chloro-4-methylpentane



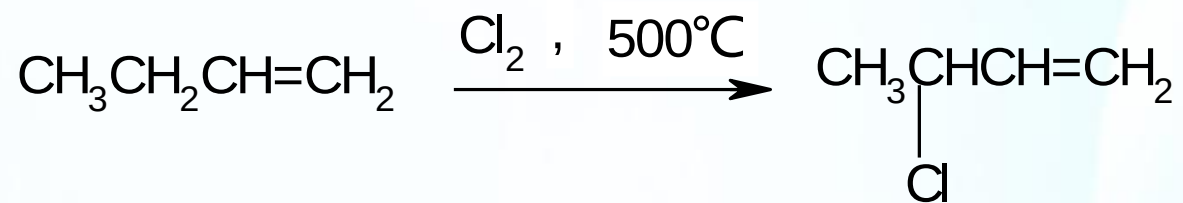
3,3,5-trichloro-2-methylhexane



4-Bromocyclohexene



① 烷烃的卤代

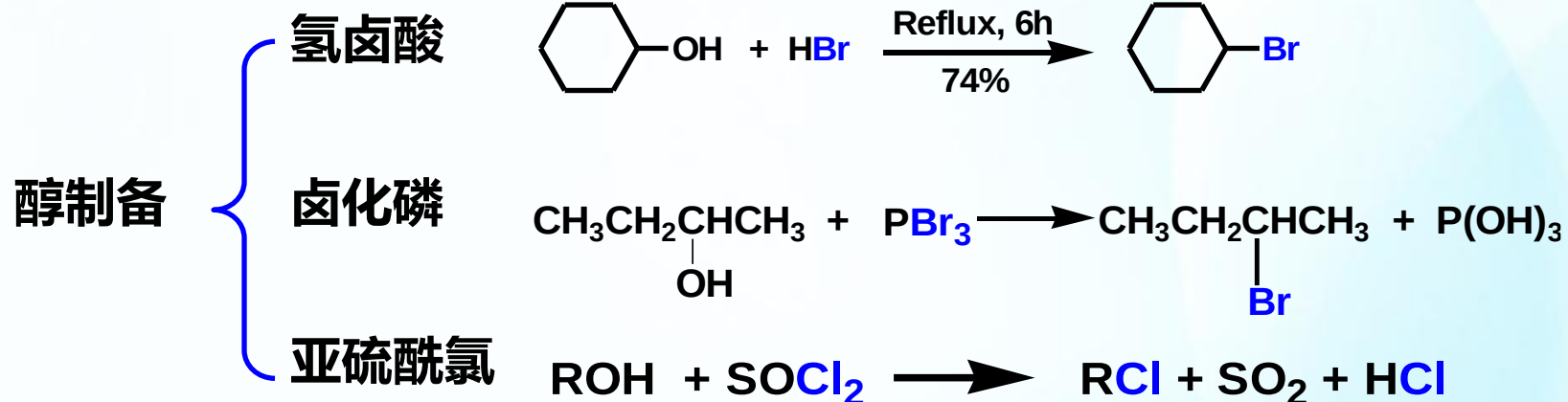


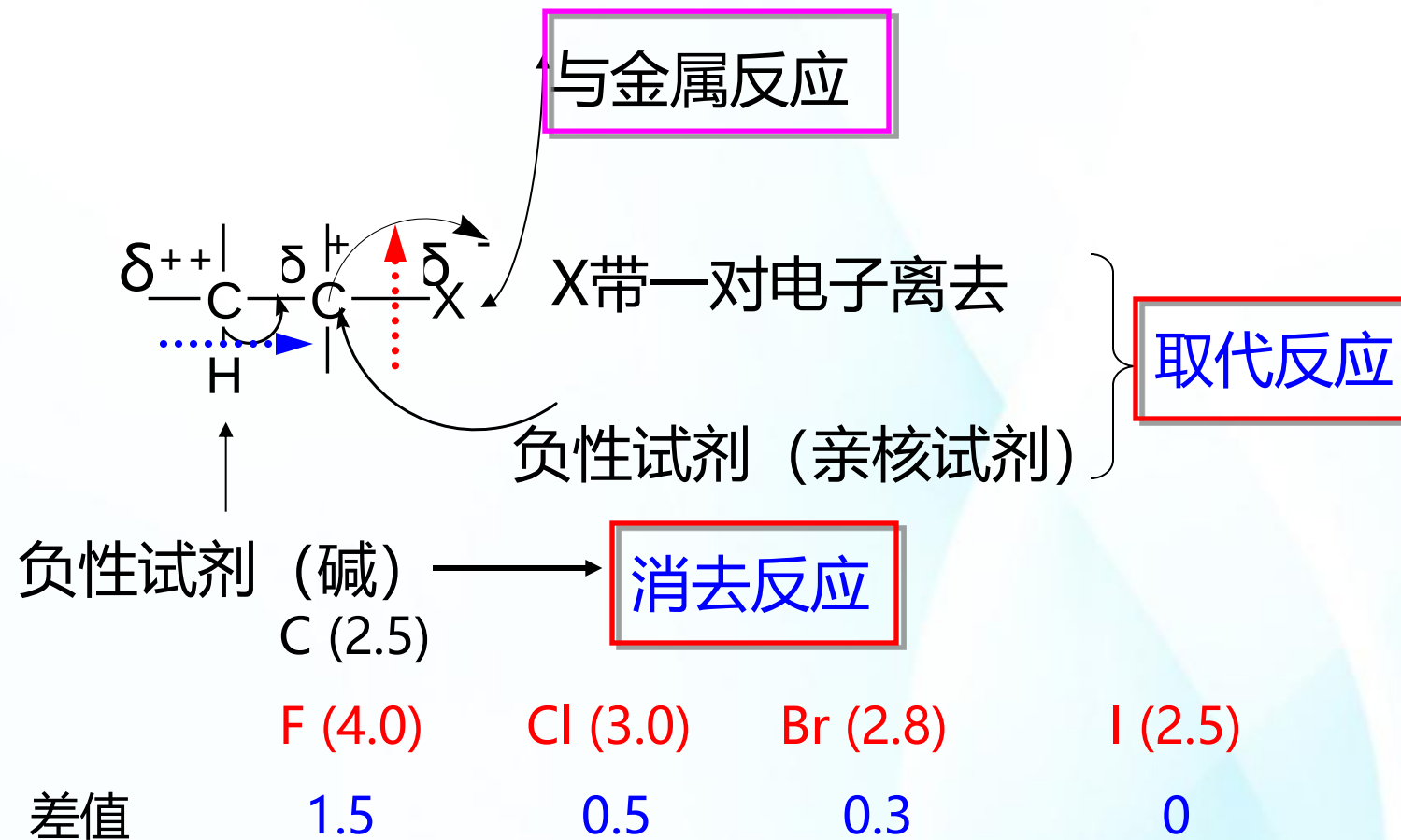


② 不饱和烃和卤化氢或卤素加成

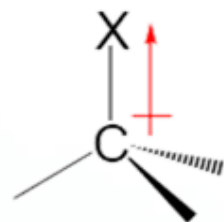


③ 由醇制备





The carbon-halogen bond length increases and the bond strength decreases as the halogen increases in size.



X=F, Cl, Br, I

	C—F	C—Cl	C—Br	C—I
键长	139	176	194	214 pm
键能	456	351	293	243 kJ / mol

	CH ₃ —F	CH ₃ —Cl	CH ₃ —Br	CH ₃ —I
偶极矩	1.82	1.94	1.79	1.64



取代基的电子效应

诱导效应 (inductive effect)

—— 键的极性通过sigma键传递的作用

共轭效应 (conjugative effect)

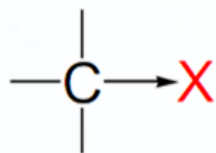
—— 相邻p轨道电子的离域运动

场效应 (field effect)

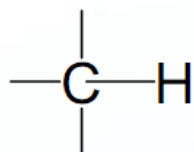
—— 合适的空间距离的基团间静电作用



诱导效应(Inductive effect):由于成键原子的电负性的不同, 使成键电子对偏向一方而发生分子极化的现象, 用I表示



吸电诱导
-I效应



比较标准



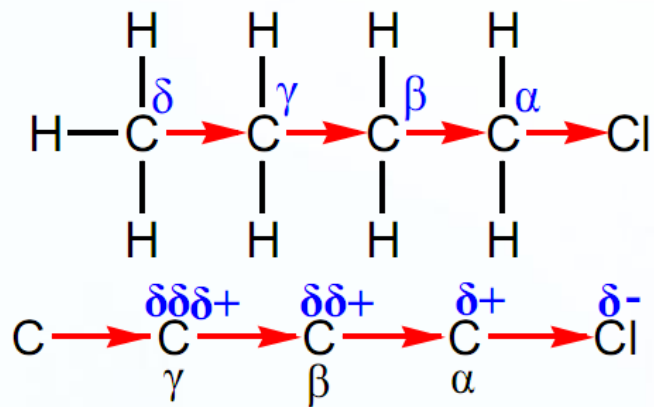
斥电诱导
+I效应

电负性顺序: $-F > -Cl > -Br > -I > -OCH_3 > -NHCOCH_3$
 $> -C_6H_5 > -CH=CH_3 > -H > -CH_3 > -C_2H_5$
 $> -CH(CH_3)_2 > -C(CH_3)_3$

H之前的基团产生吸电诱导, H之后的基团产生斥电诱导



卤素的诱导（吸电子）效应



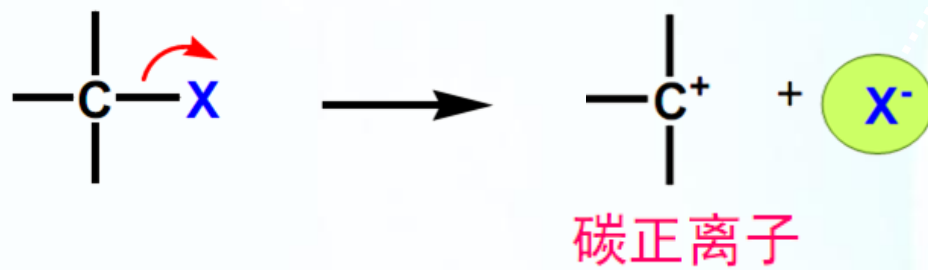
H	C	N	O	F
21	25	3.0	3.5	4.0
		P	S	Cl
		2.1	2.5	3.0
				Br
				2.8
				I
				2.5

一些元素
的电负性



C-X键的异裂

① 自身异裂



X 总是以负离子形式离去

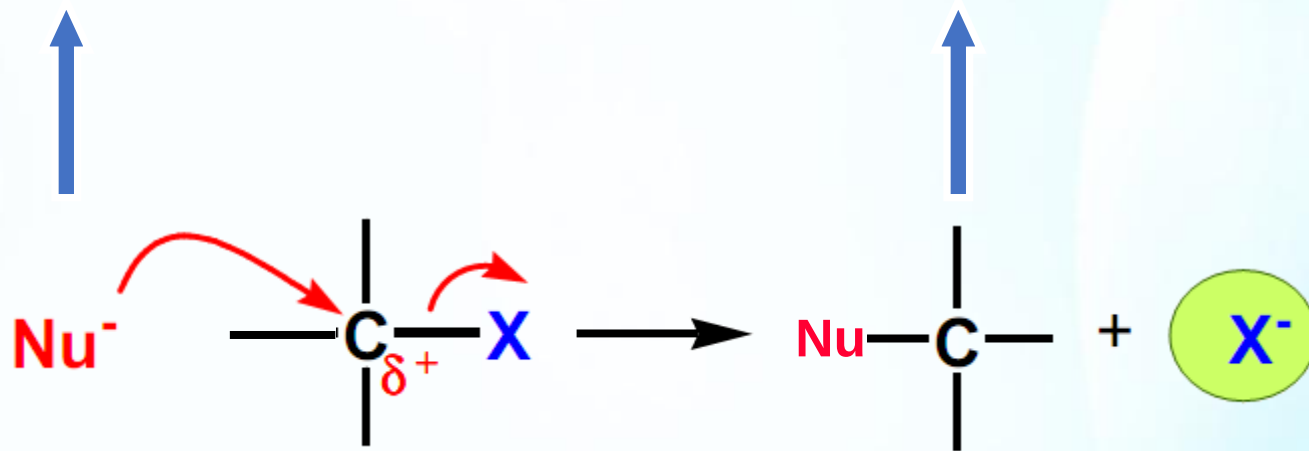


C-X键的异裂

② 在亲核试剂作用下异裂

亲核试剂 (*Nucleophile*) :
一些带有未共享电子对的分子
或负离子, 与正电性碳反应时称为
亲核试剂。

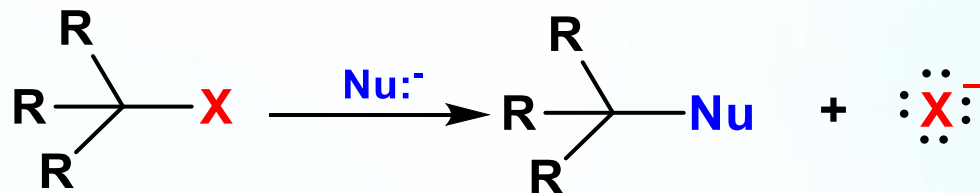
亲核试剂(Nu)取代了卤素(X)
——亲核取代反应(S_N 反
应, *Nucleophilic*
Substitution Reaction)



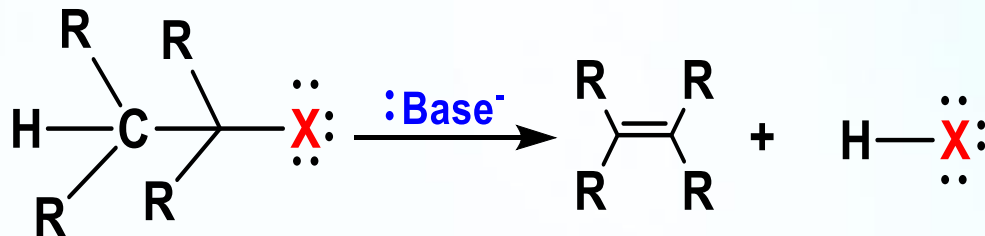


3. What are the characteristic Reactions of Haloalkanes?

The major reactions undergone by alkyl halides are nucleophilic substitution where an attacking nucleophile replaces the halogen, and elimination where the alkyl halide loses HX and is converted to an alkene.



Nucleophilic
substitution



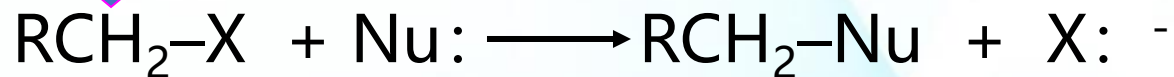
Elimination



(1) 亲核取代反应 (nucleophilic substitution)

由亲核试剂进攻电子云密度较低的中心碳原子而引起的取代反应，用 S_N 表示。

中心碳原子



底物

亲核试剂

产物

离去基团

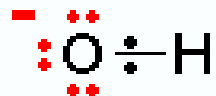
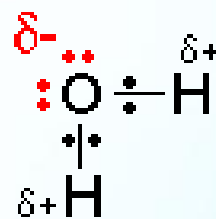
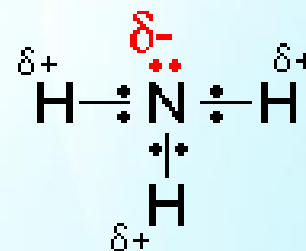


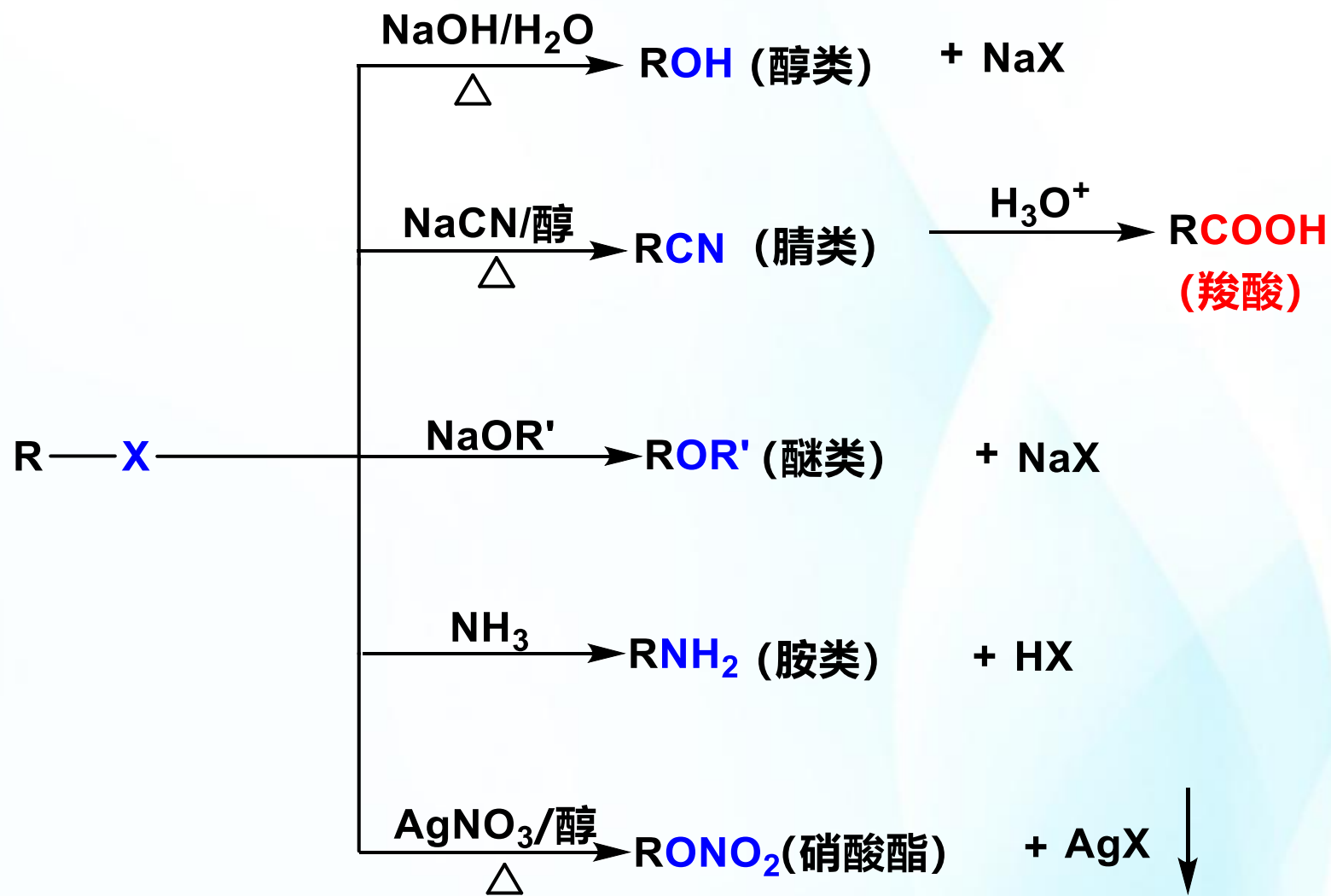
受进攻的对象

常见的亲核试剂有：



一般是负离子或带孤电子对的中性分子,用 $Nu:$ 或 Nu^- 表示。



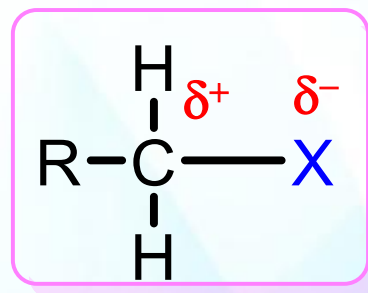




拔河比赛



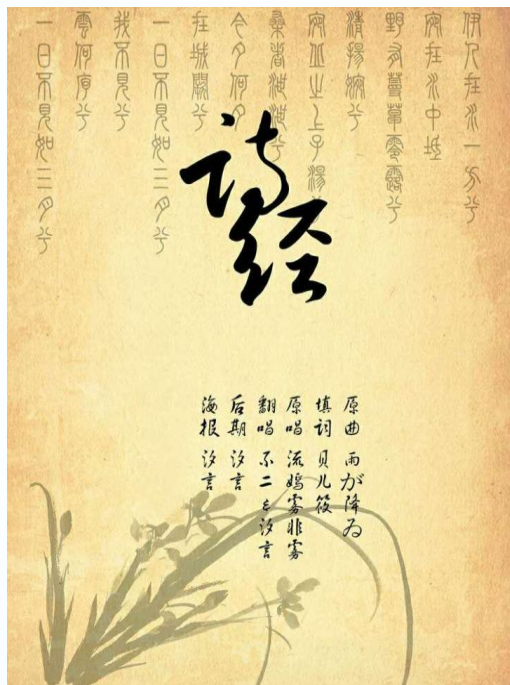
分子微观世界



“电子争夺赛”

极化C-X键

单分子亲核取代反应

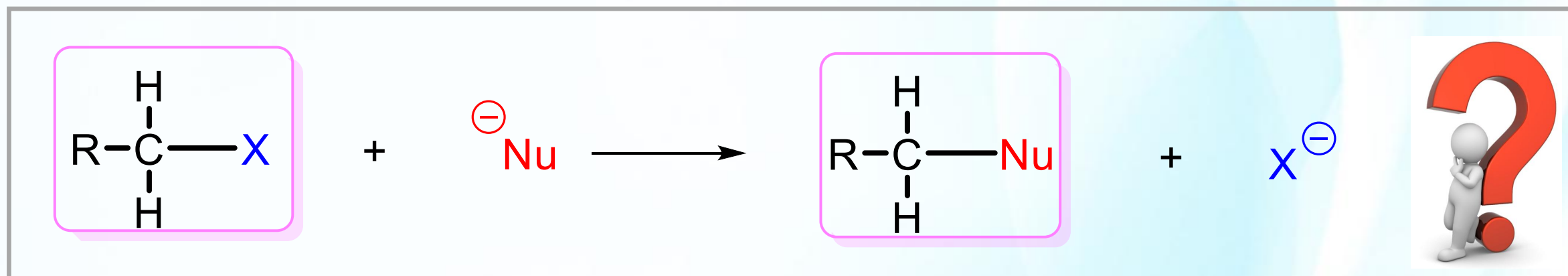


维**鹊**有巢，维**鸠**居之

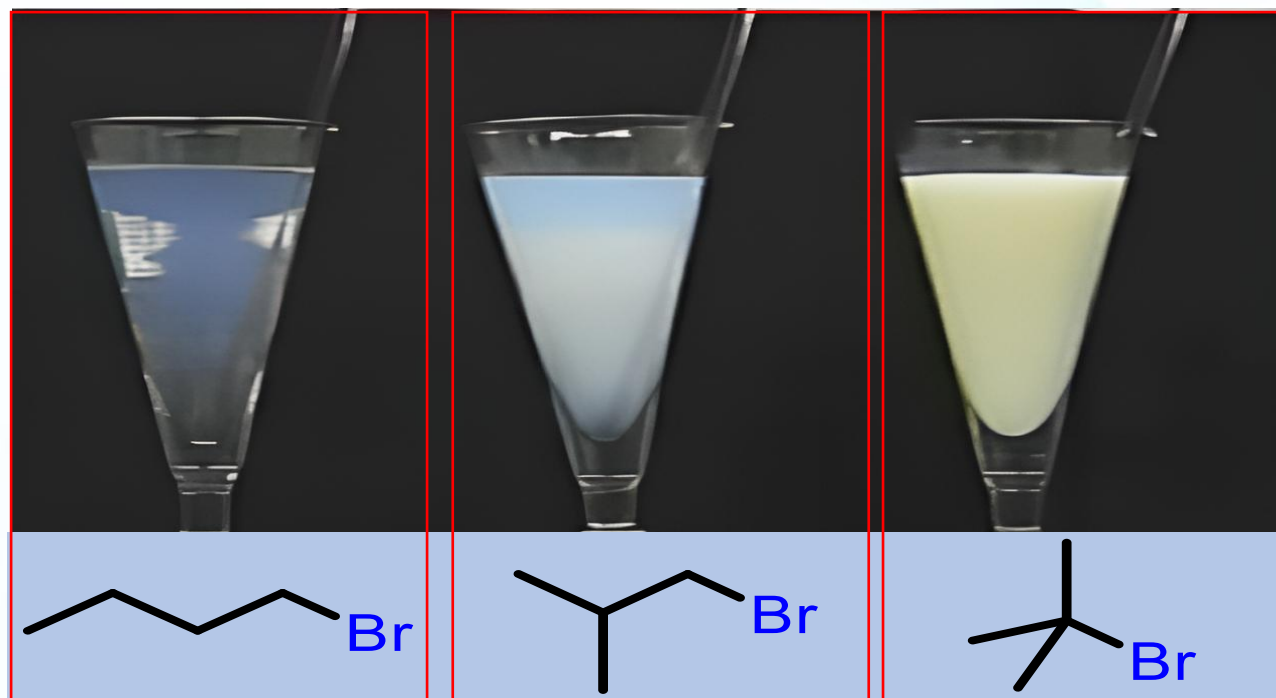
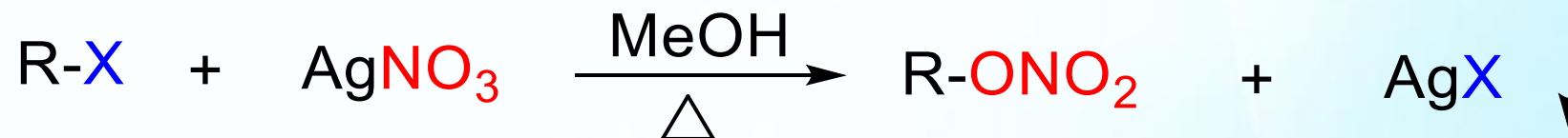
《诗经·召南·鹊巢》



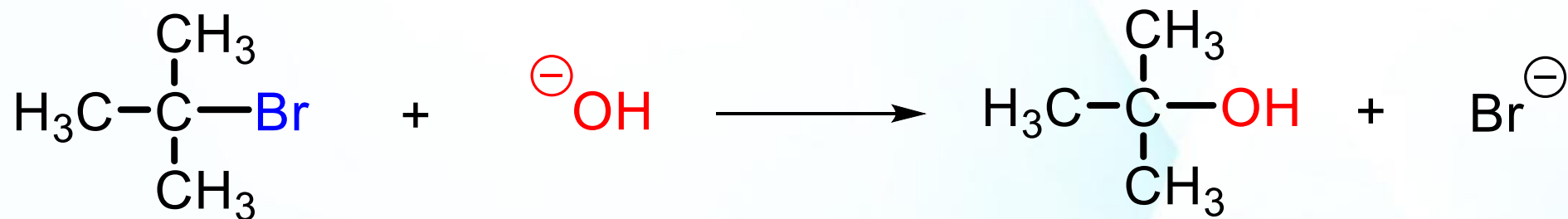
鸠占**鹊**巢



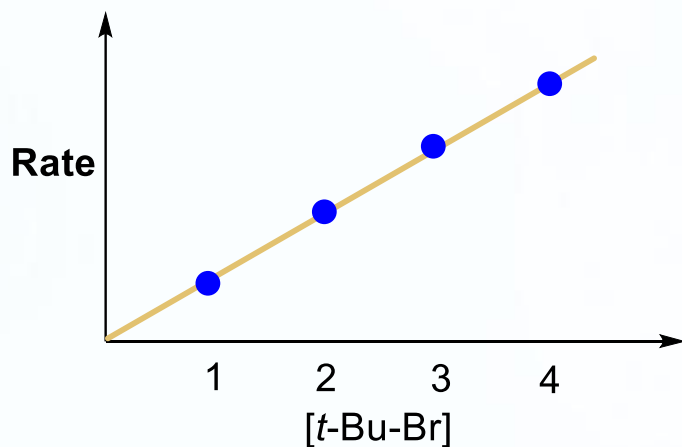
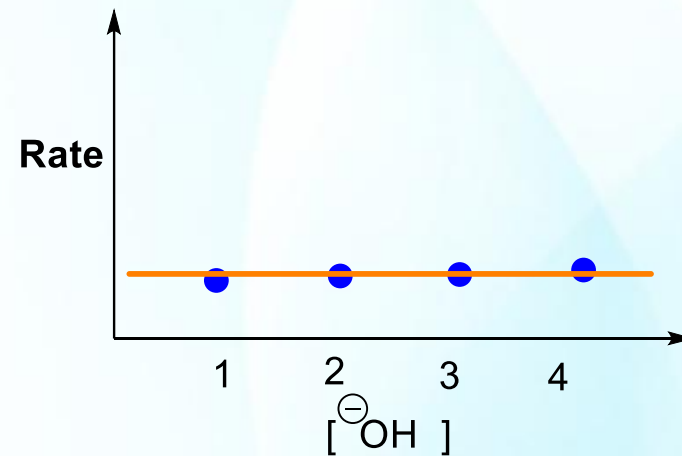
1. 亲核取代反应实验现象

AgNO₃溶液

2. 单分子亲核取代反应实验



实验结果:

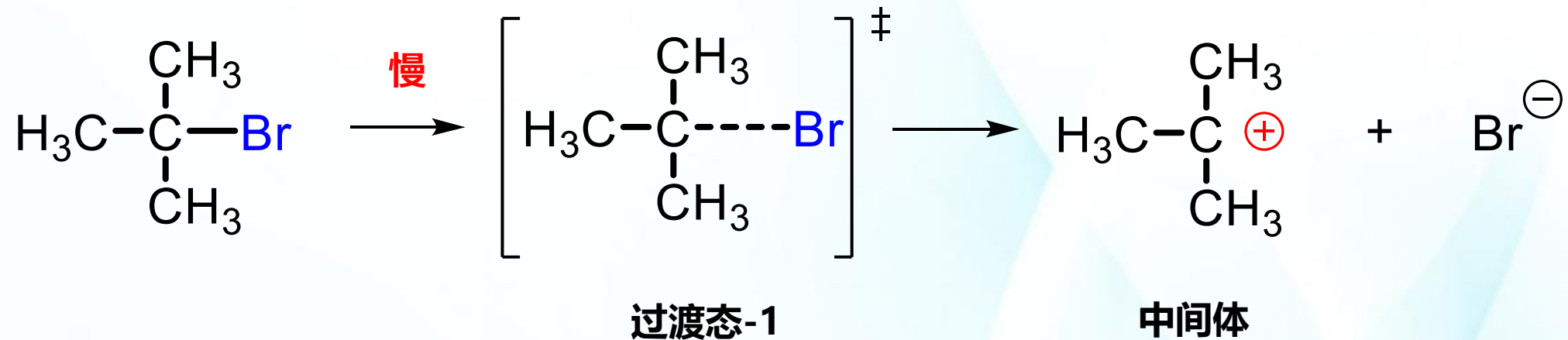


$$v = k[(\text{CH}_3)_3\text{CBr}]$$

说明该反应过程的只由一种组分决定, 这类反应就称为单分子亲核取代反应 ($\text{S}_{\text{N}}1$)

3.单分子亲核取代反应 (S_N1) 机理

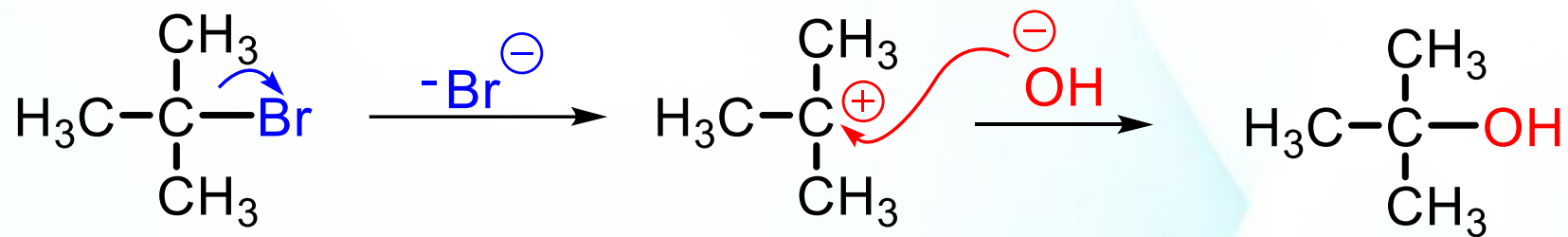
Step 1



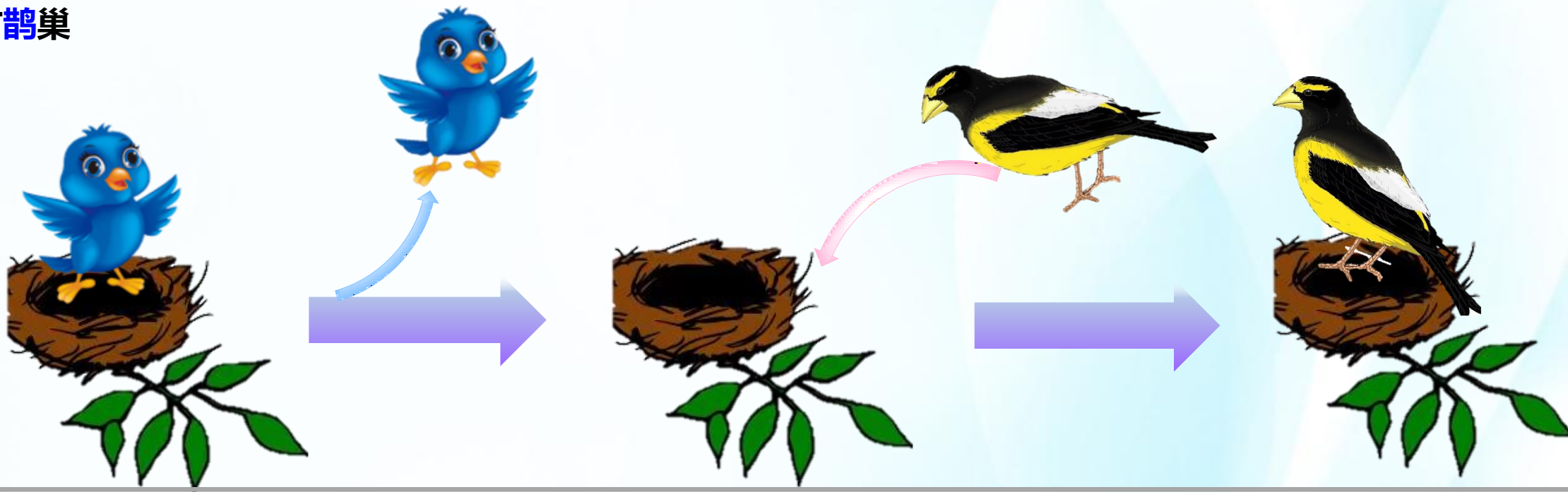
Step 2



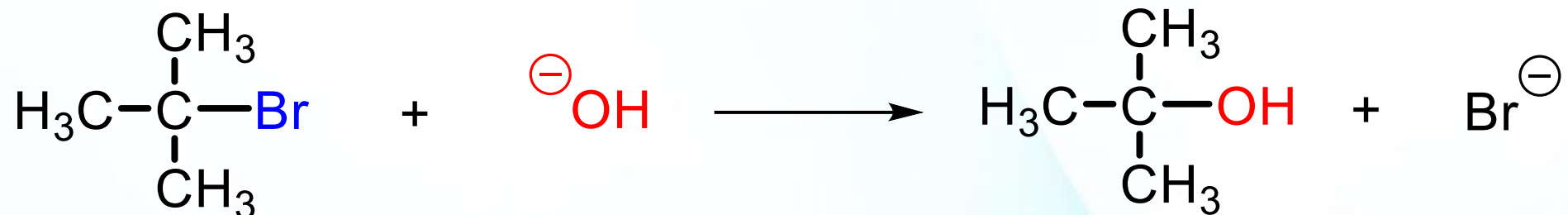
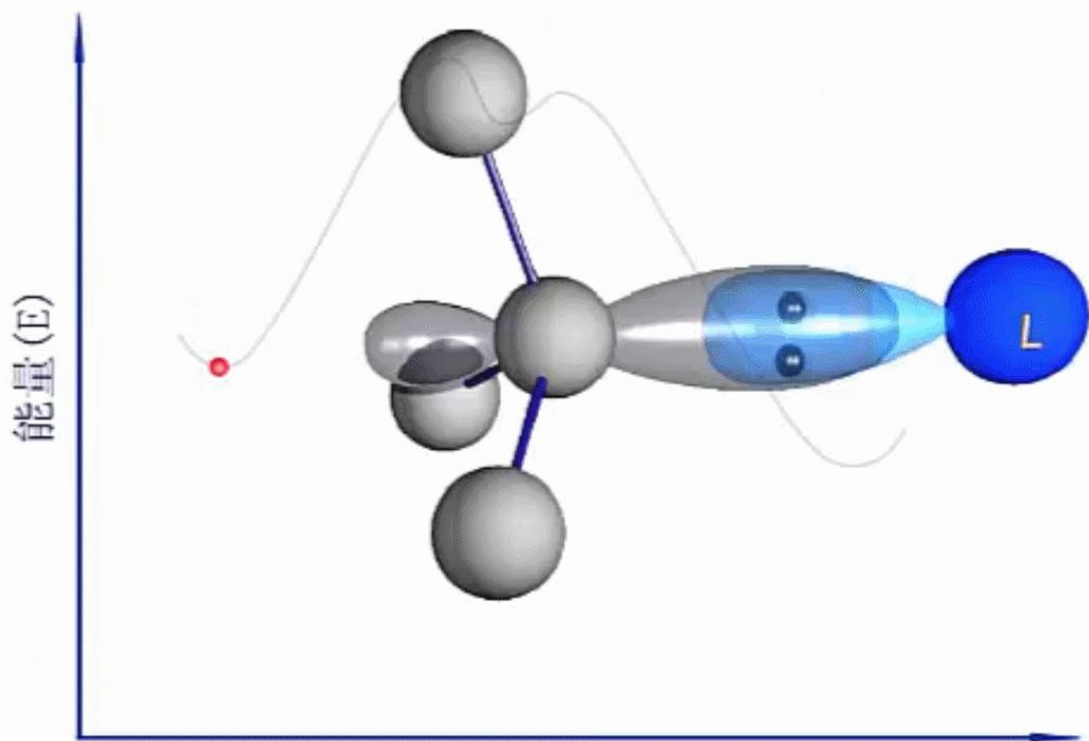
3. 单分子亲核取代反应 (S_N1) 机理



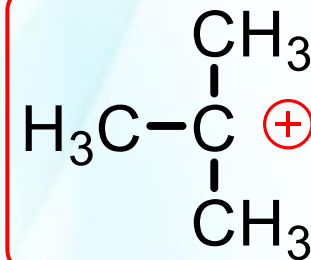
鸠占鹊巢



单分子亲核取代反应



- ◆ 离去基团离开，形成中间体
- ◆ 中间体能量高低影响反应活性
- ◆ 经历一个中间体，两个过渡态，两步反应





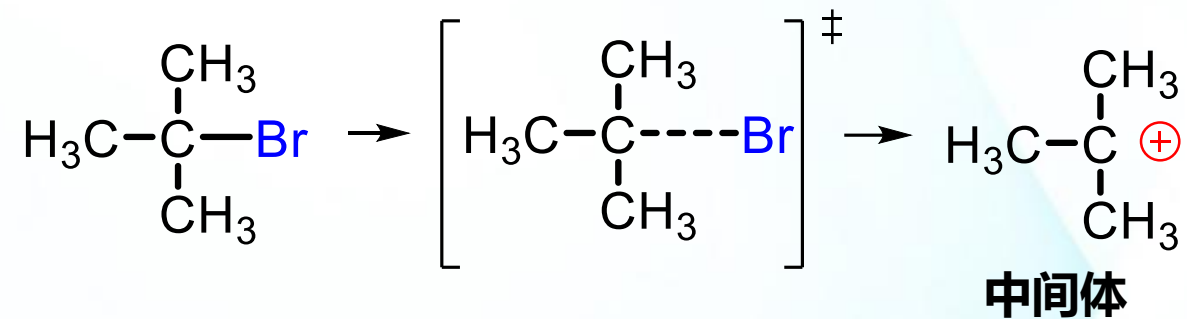
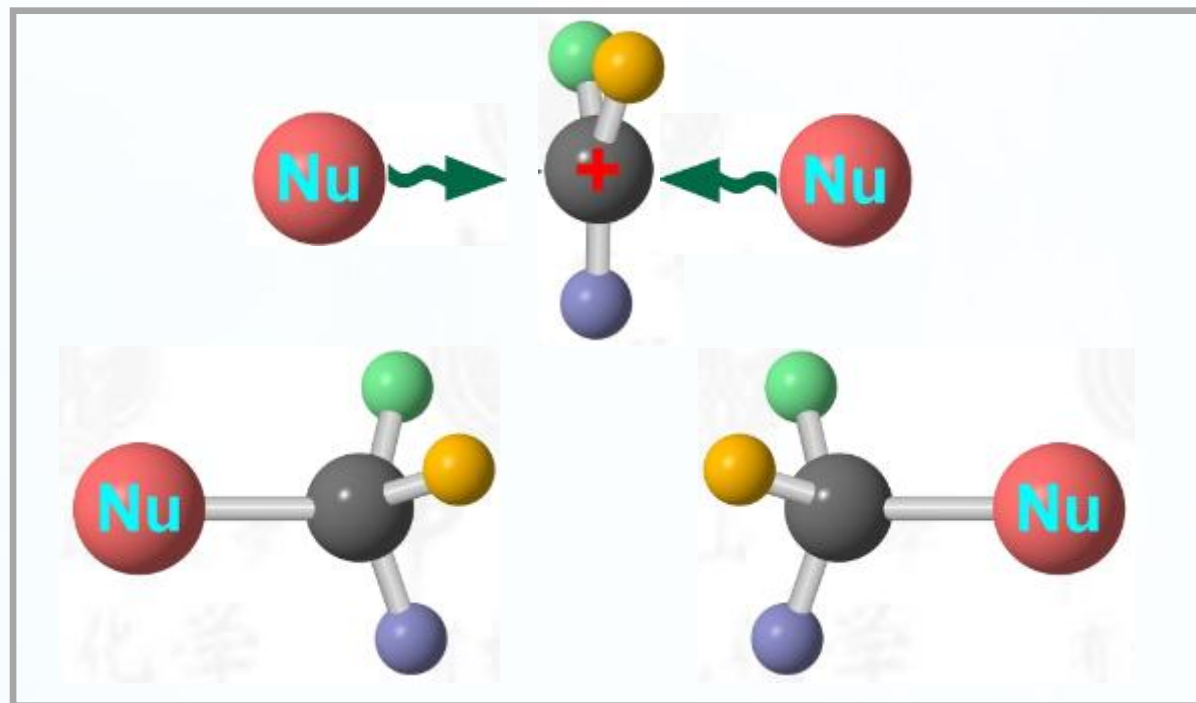
George Andrew Olah
(1927-2017)



在超强酸稳定碳正离子的研究中有杰出贡献，获得1994年诺贝尔化学奖！

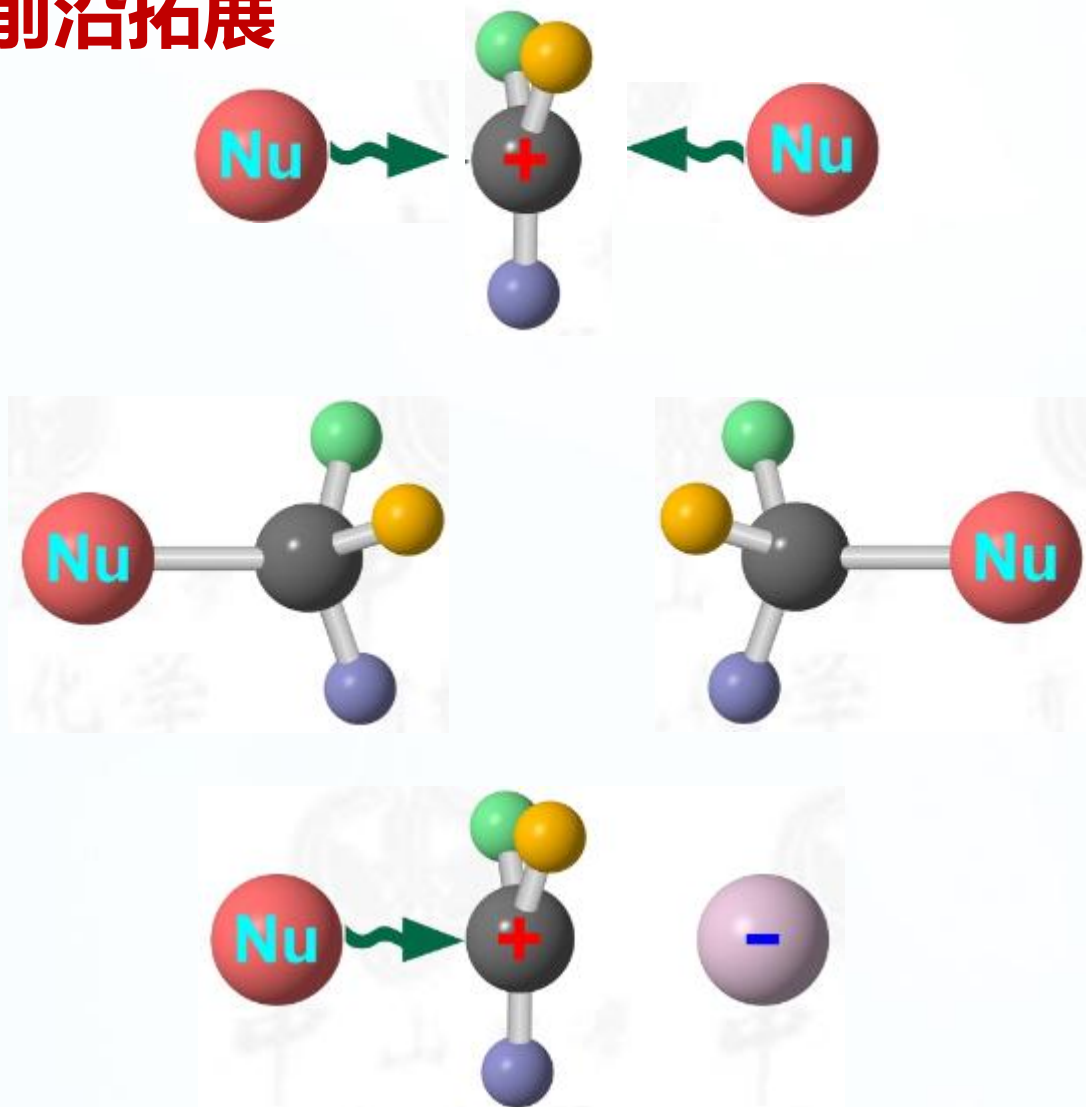


4. S_N1 反应的立体化学



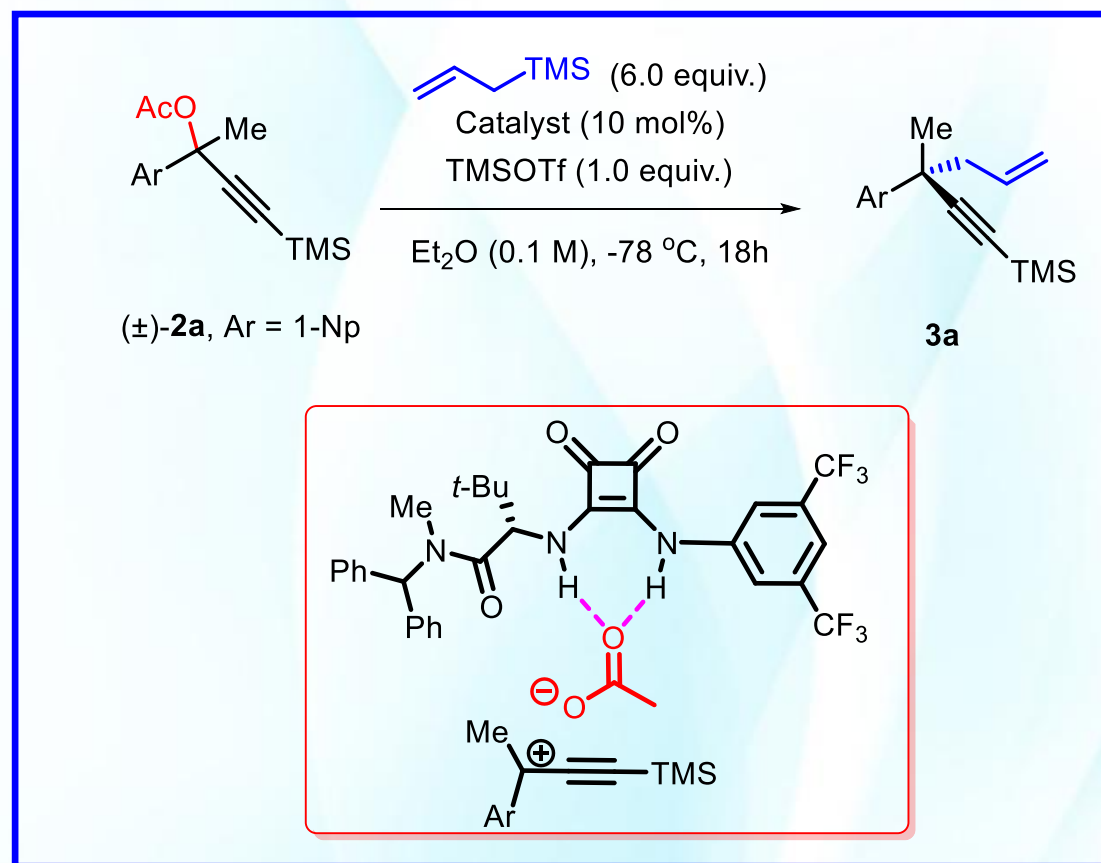
- ◆ 中间体为 sp^2 杂化，平面构型
- ◆ 亲核试剂从两边进攻，机会均等
- ◆ 手性原料会发生外消旋化

5. 前沿拓展



离子对作用，可以在一定程度上影响亲核进攻

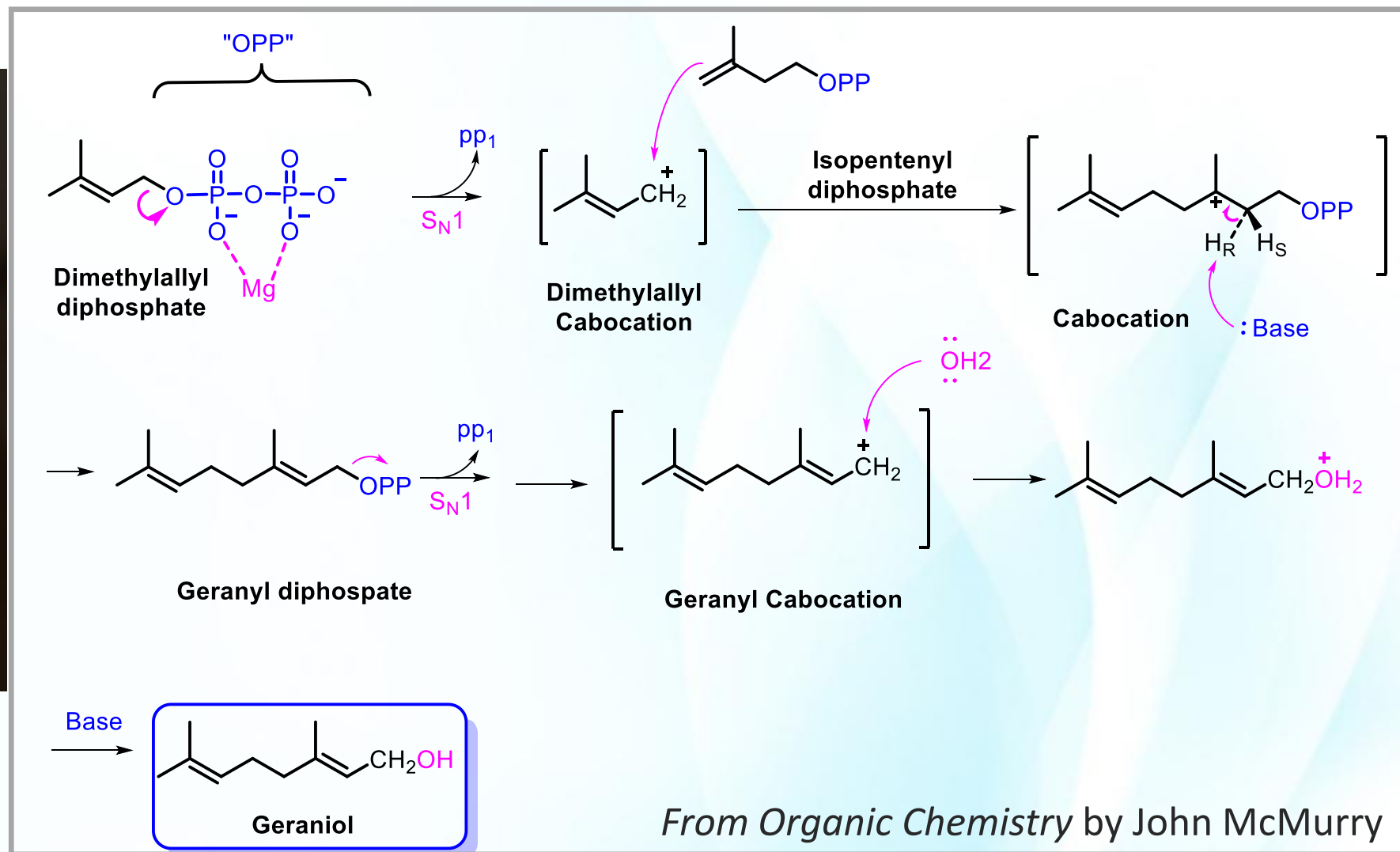
- ◆ 亲核试剂从两边进攻，机会均等
- ◆ 手性原料会发生外消旋化



自然界中，生物合成香叶醇的过程，主要经历了关键的单分子亲核取代反应

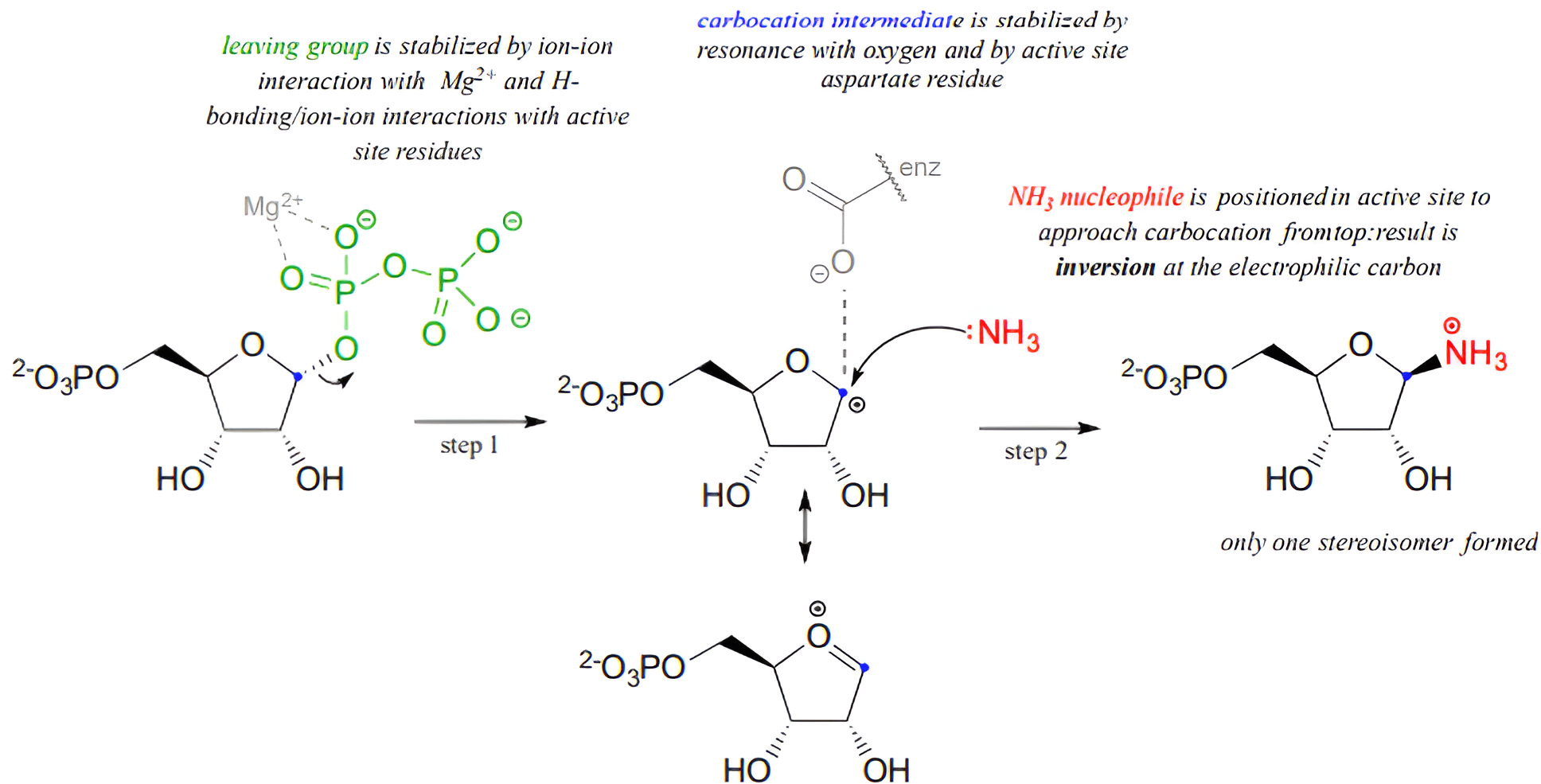


赠人玫瑰，手留余香



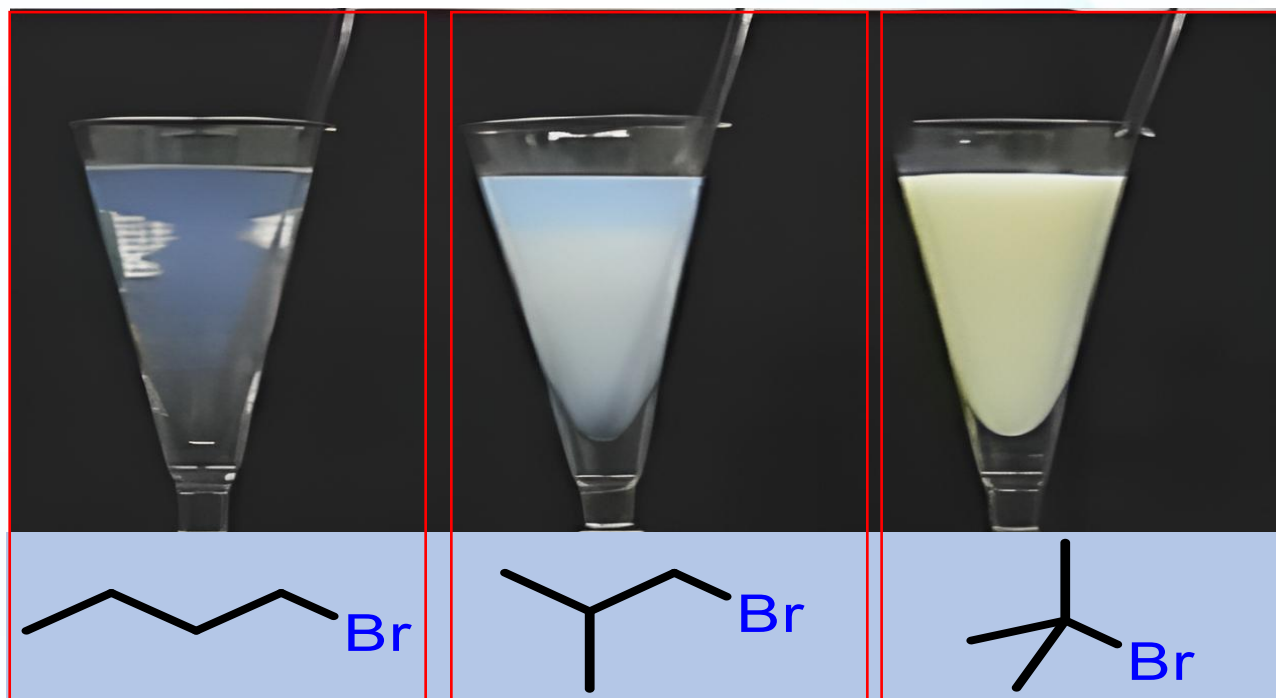
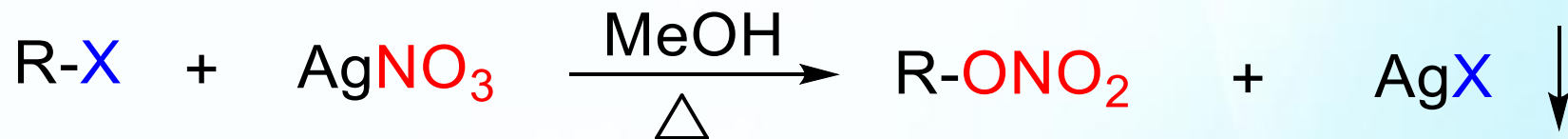
From Organic Chemistry by John McMurry

人体内的遗传物质的合成过程也涉及 S_N1 反应历程



思考题：不同的烷基溴代物产生不同的实验现象？

AgNO₃溶液

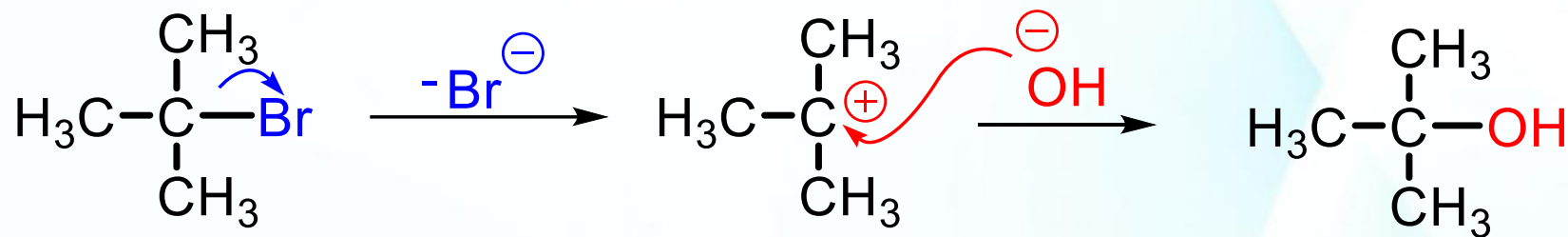




单分子亲核取代反应

本节要点总结

◆ 单分子亲核取代反应及反应机理；



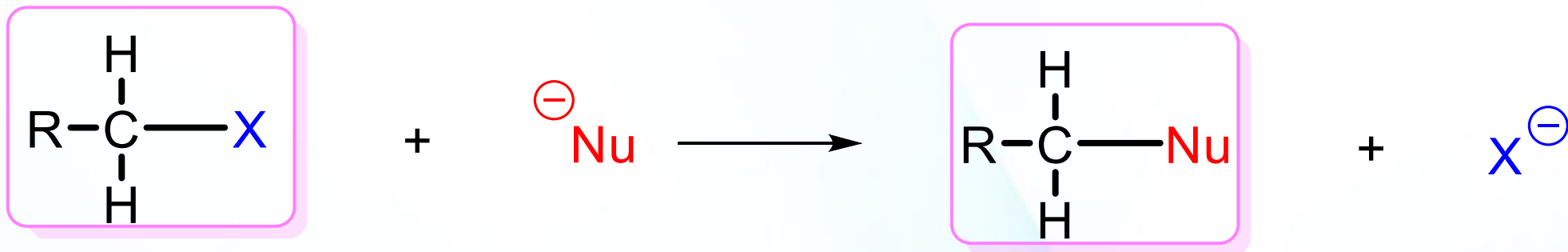
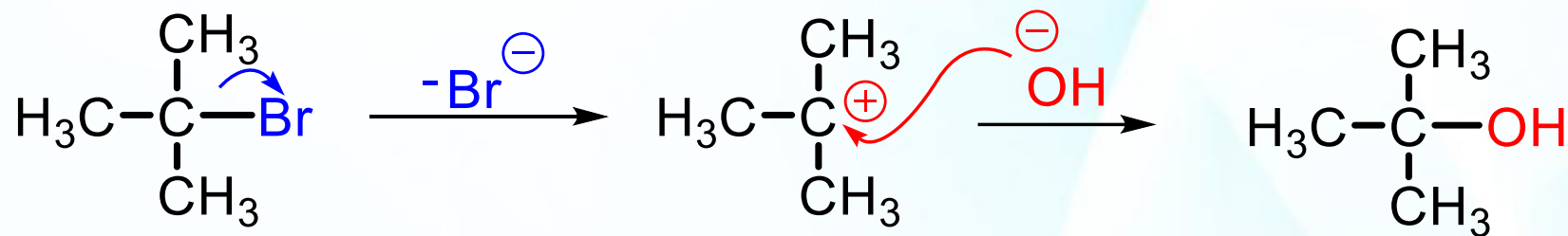
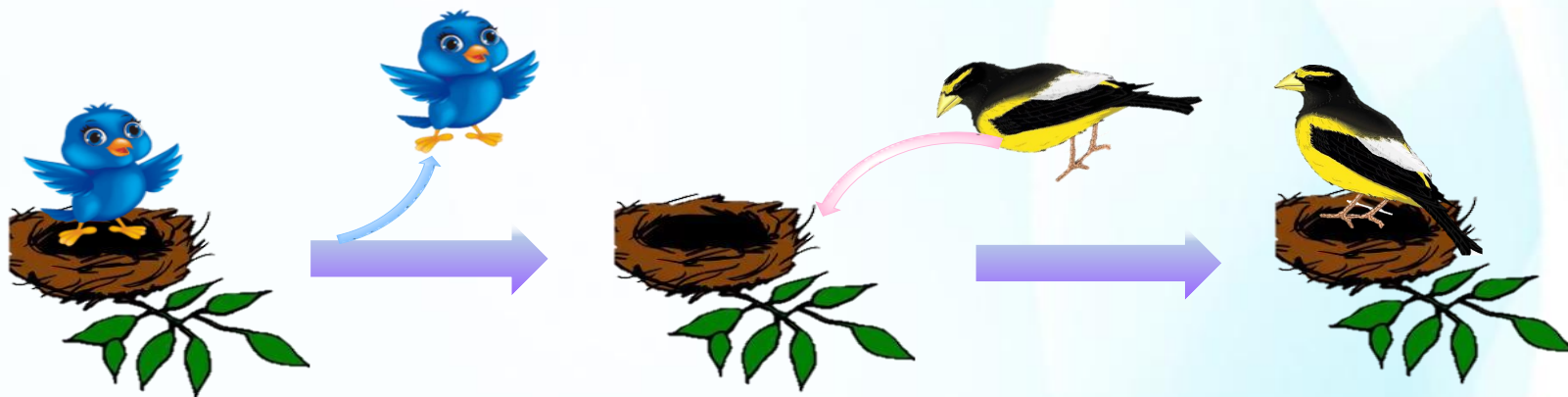
鸠占鹊巢

◆ 单分子亲核取代反应特点

✓ 一个中间体（决速步骤），两个过渡态

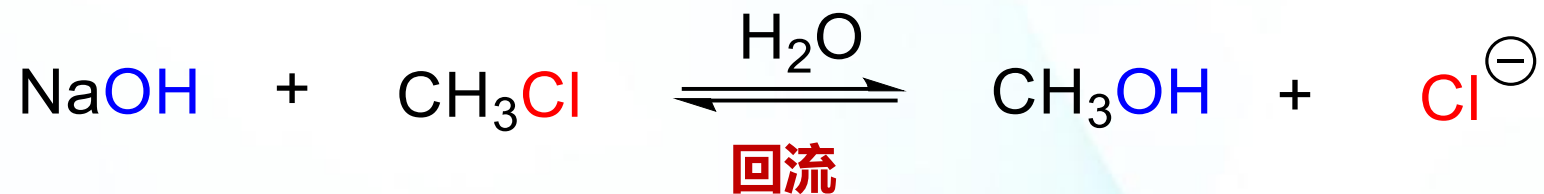
✓ 立体化学：产生消旋产物

课后思考题：影响亲核取代反应的因素有哪些，还有其他反应形式吗？

**S_N1反应****鸠占鹊巢**

亲核取代反应有没有其他反应历程呢？

1.实验事实

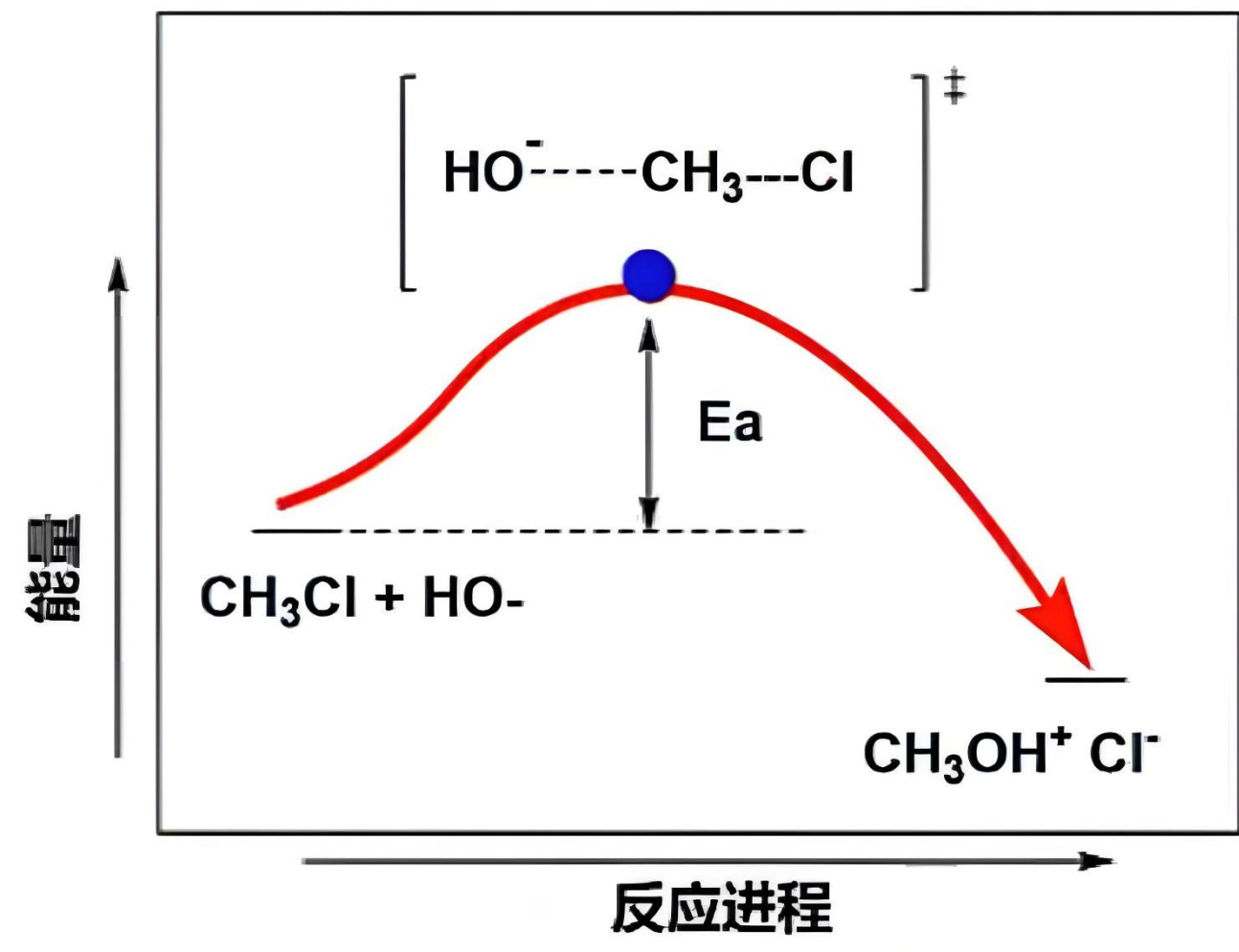


反应次数	起始[CH ₃ Cl]	起始[OH ⁻]	反应速率(molL ⁻¹ S ⁻¹)
1	0.0010	1.0	4.9 × 10 ⁻⁷
2	0.0020	1.0	9.8 × 10 ⁻⁷
3	0.0010	2.0	9.8 × 10 ⁻⁷
4	0.0020	2.0	19.6 × 10 ⁻⁷

$$v = k [\text{CH}_3\text{Cl}][\text{OH}^-]$$

双分子参与的亲核取代过程S_N2

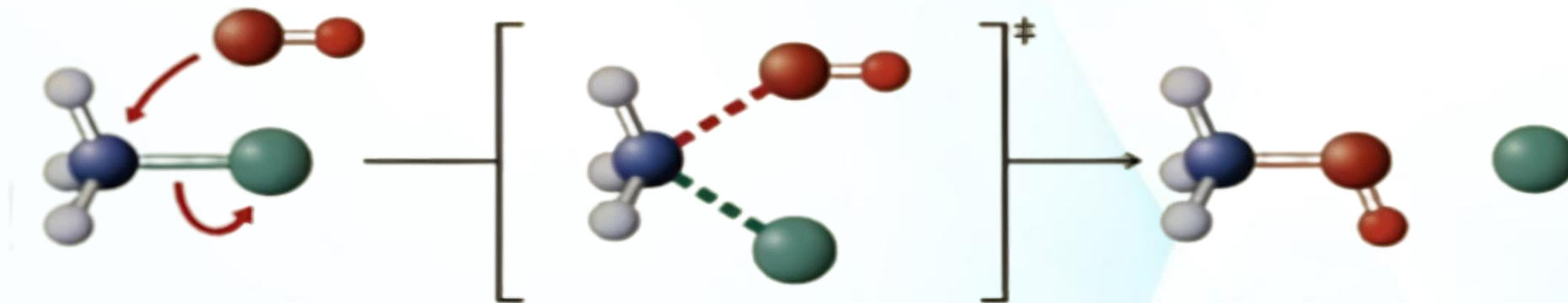
2. 反应活化能



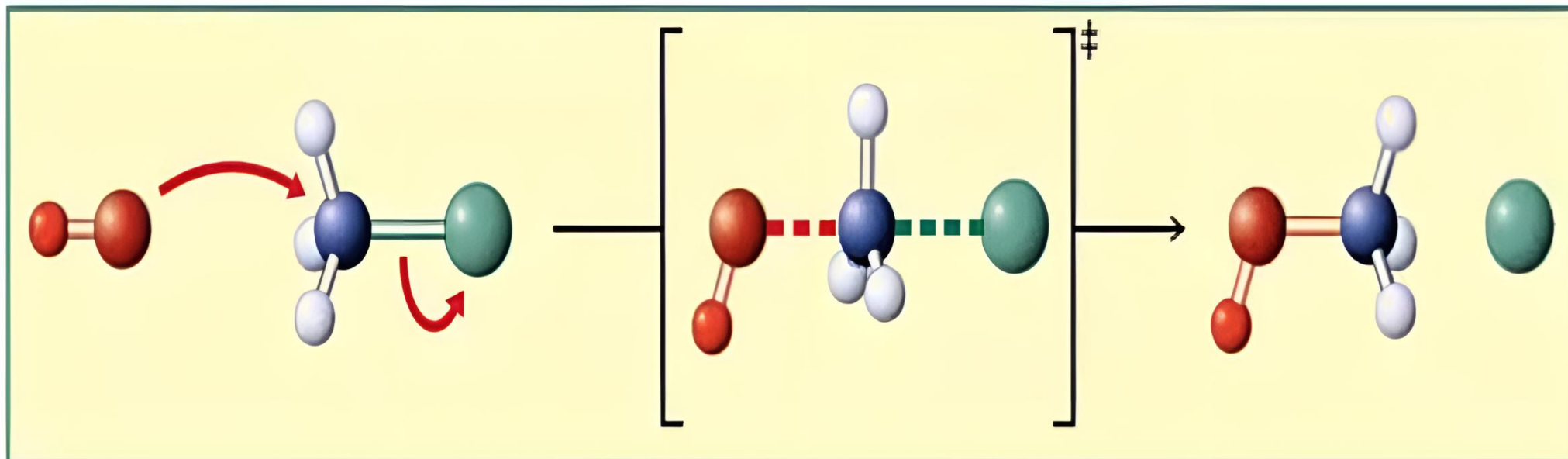
动力学反应特征：一步反应，在动力学上是二级反应

3. 反应机理

正面进攻



背面进攻



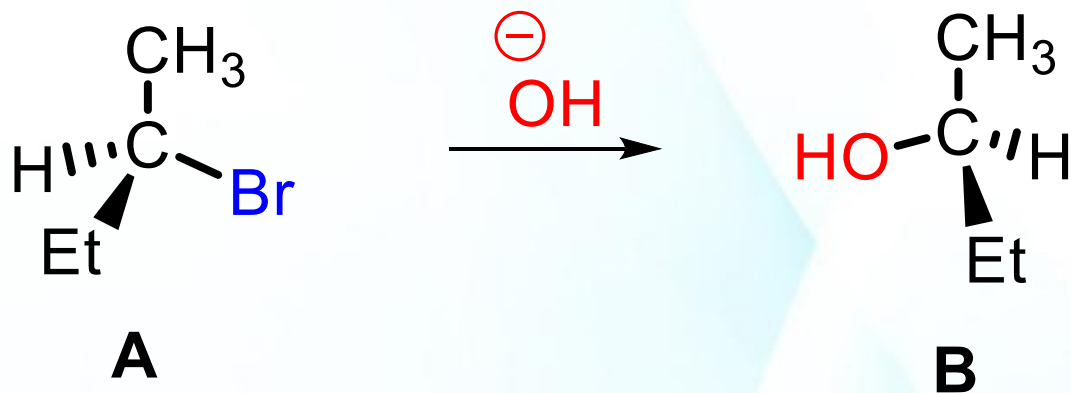
如何证明?

大胆假设, 小心求证!

3. 反应机理



Paul Walden
(1863-1957)



□ 动力学反应特征：在动力学上是二级反应

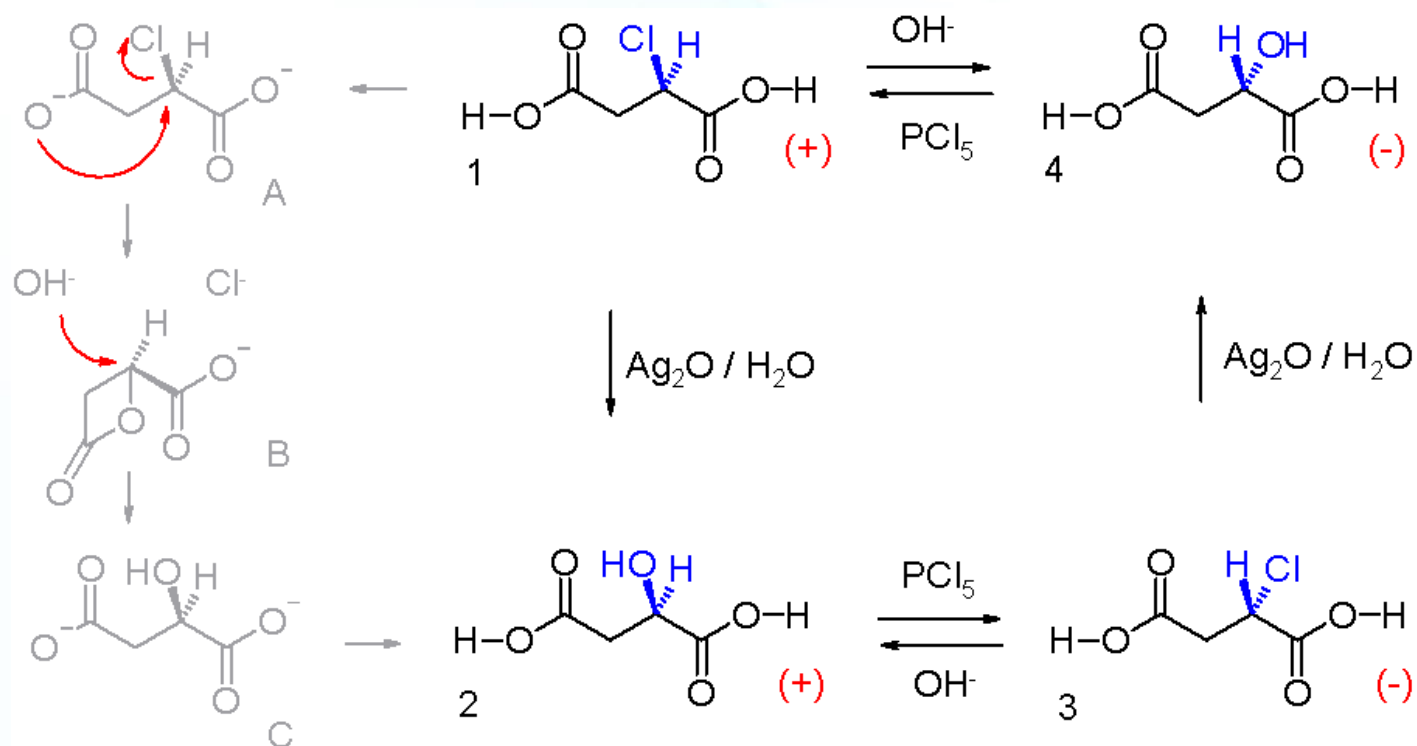
□ A : $[\alpha]_D = + 36.0^\circ$ B : $[\alpha]_D = - 13.5^\circ$

3. 反应机理



Paul Walden
(1863-1957)

Walden循环

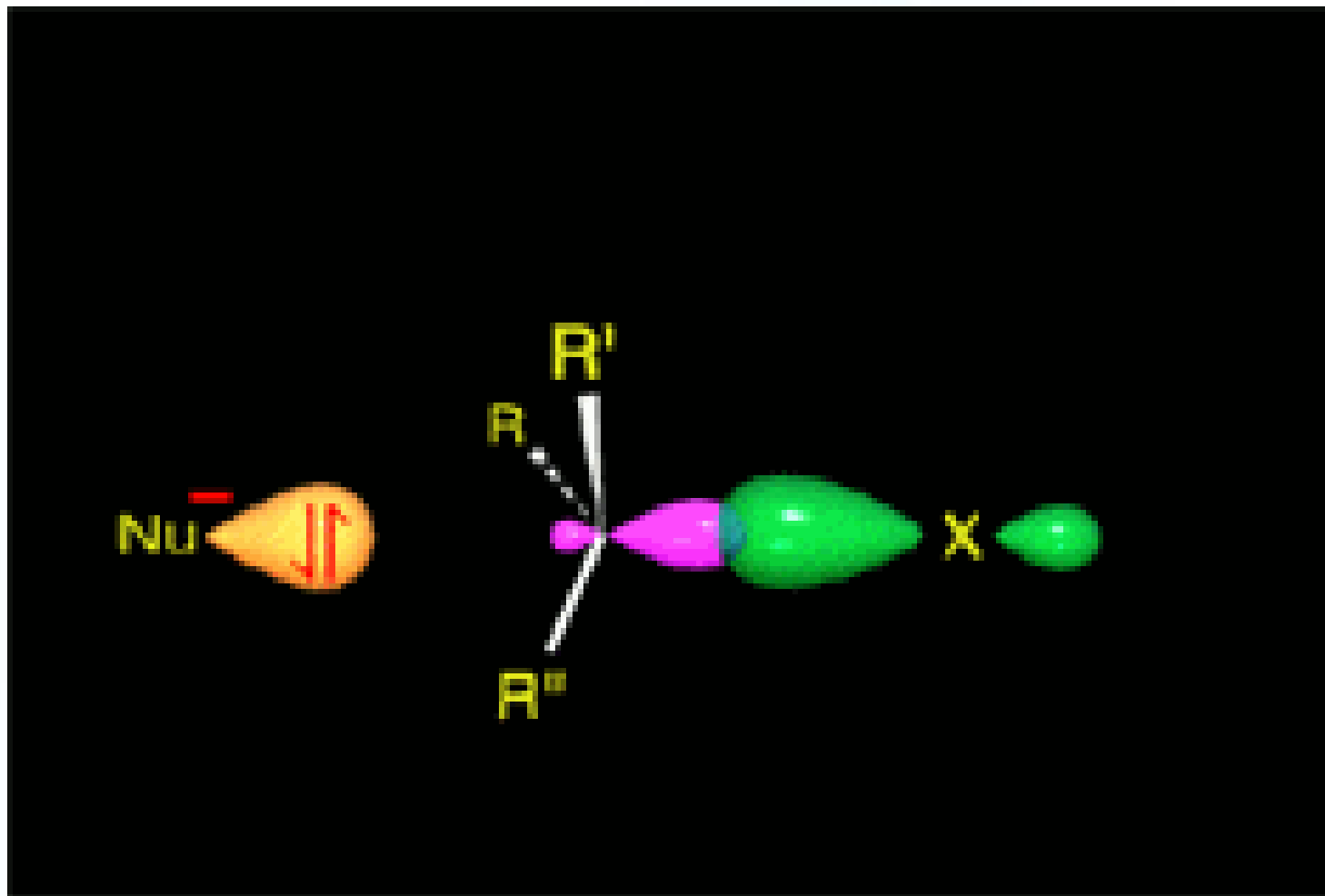


让苹果酸构型发生转化的方法

Walden翻转



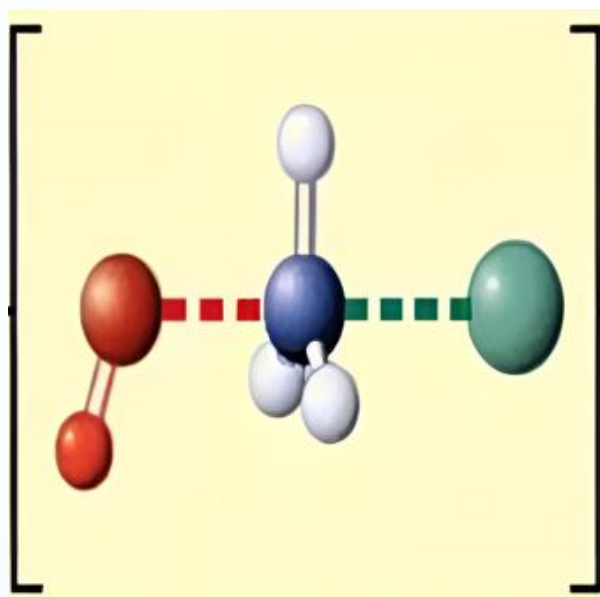
3. 反应机理



双分子亲核取代反应动画示意图

4. 前沿动态:

课后阅读:



S_N2 反应经典过渡态

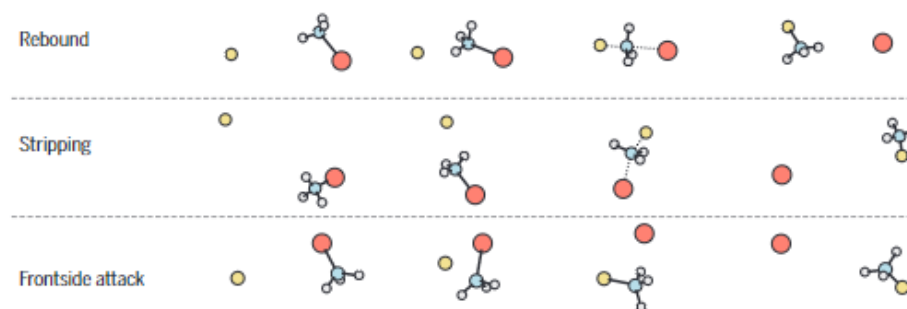
实际的 S_N2 反应过程极其复杂

理性看待“经典”，学会批判思维

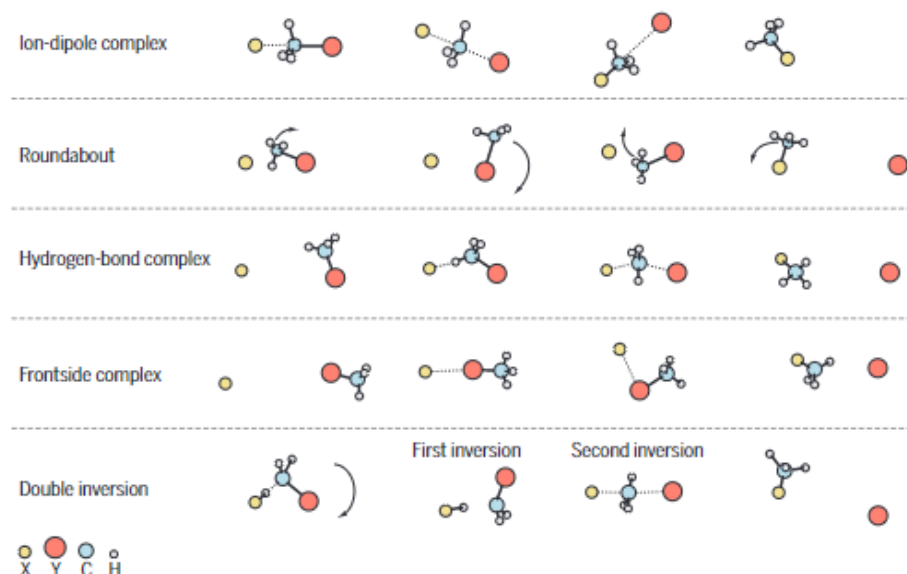
ORGANIC CHEMISTRY

Rethinking the S_N2 reaction

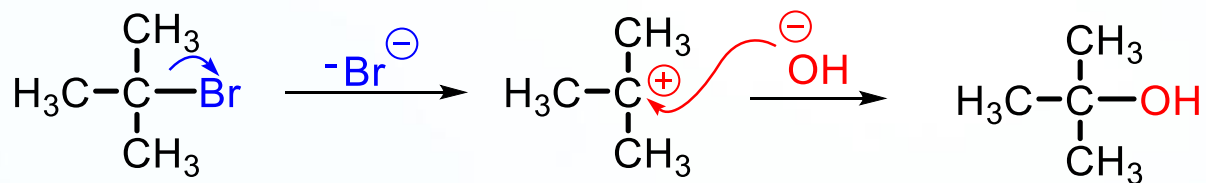
Direct gas-phase S_N2 mechanisms



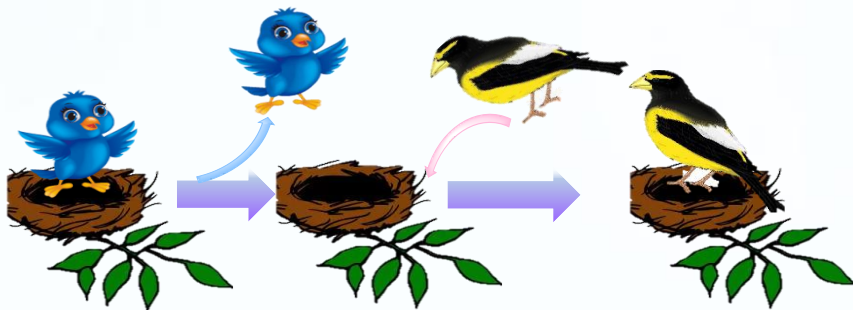
Indirect gas-phase S_N2 mechanisms



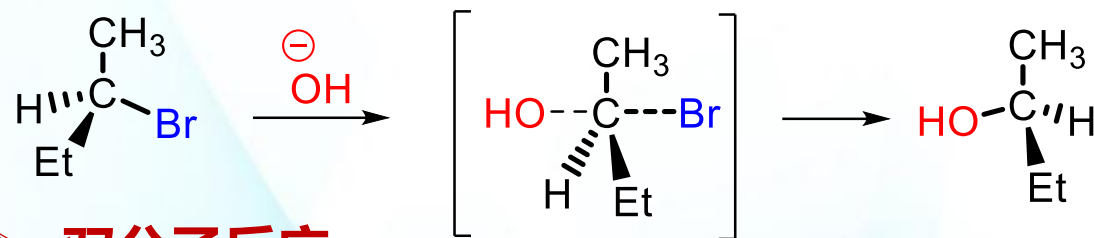
单分子 (S_N1) 亲核取代反应



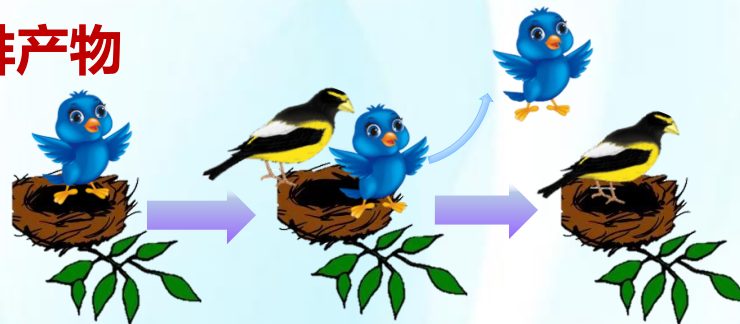
- 单分子反应
- 分步进行 (两步)
- 有碳正离子中间体生成
- 构型转化+构型保持
- 有重排产物



双分子 (S_N2) 亲核取代反应

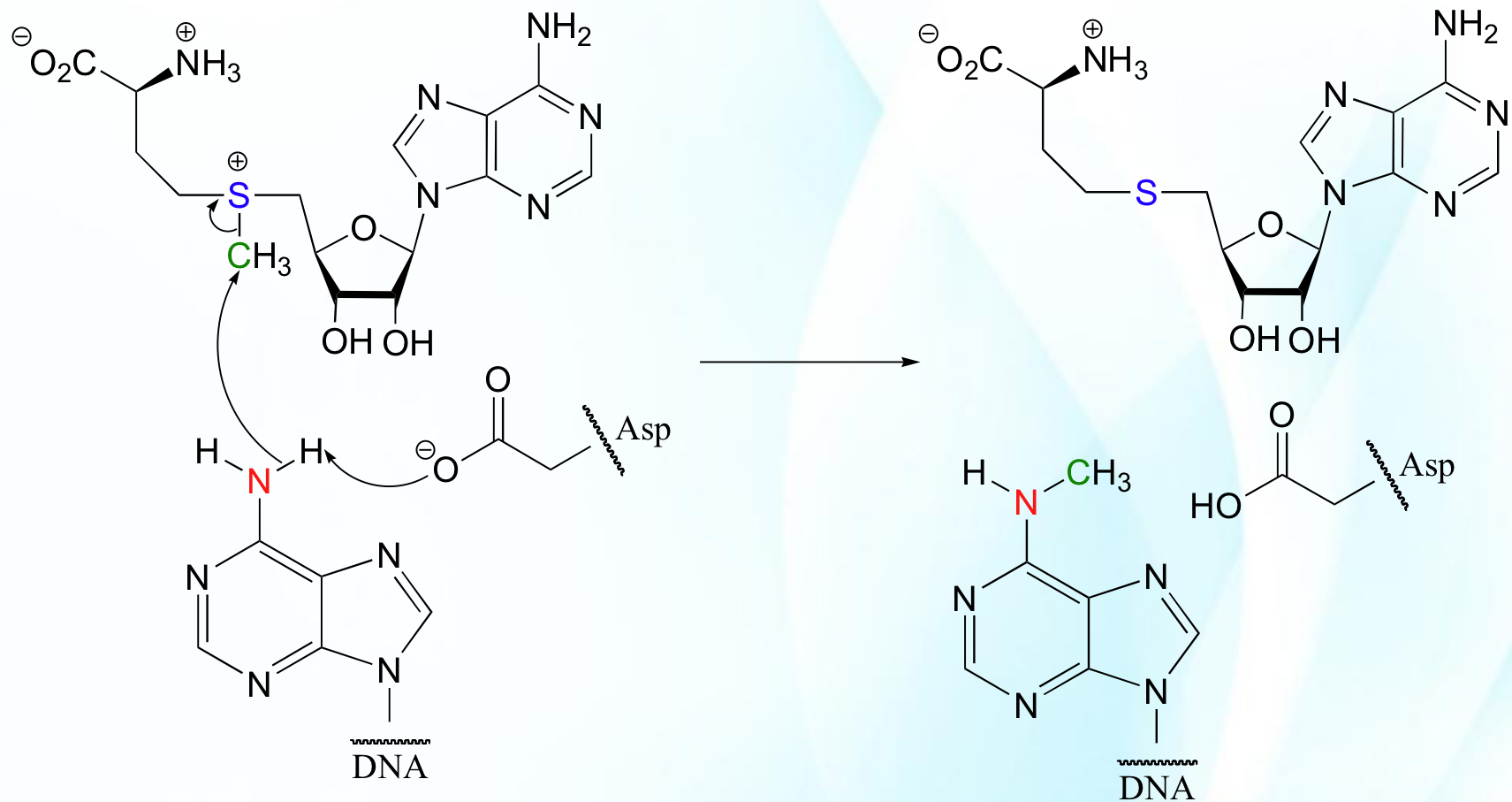


- 双分子反应
- 一步完成
- 形成过渡态, 无碳正离子中间体生成
- 构型转化 (Walden翻转)
- 无重排产物

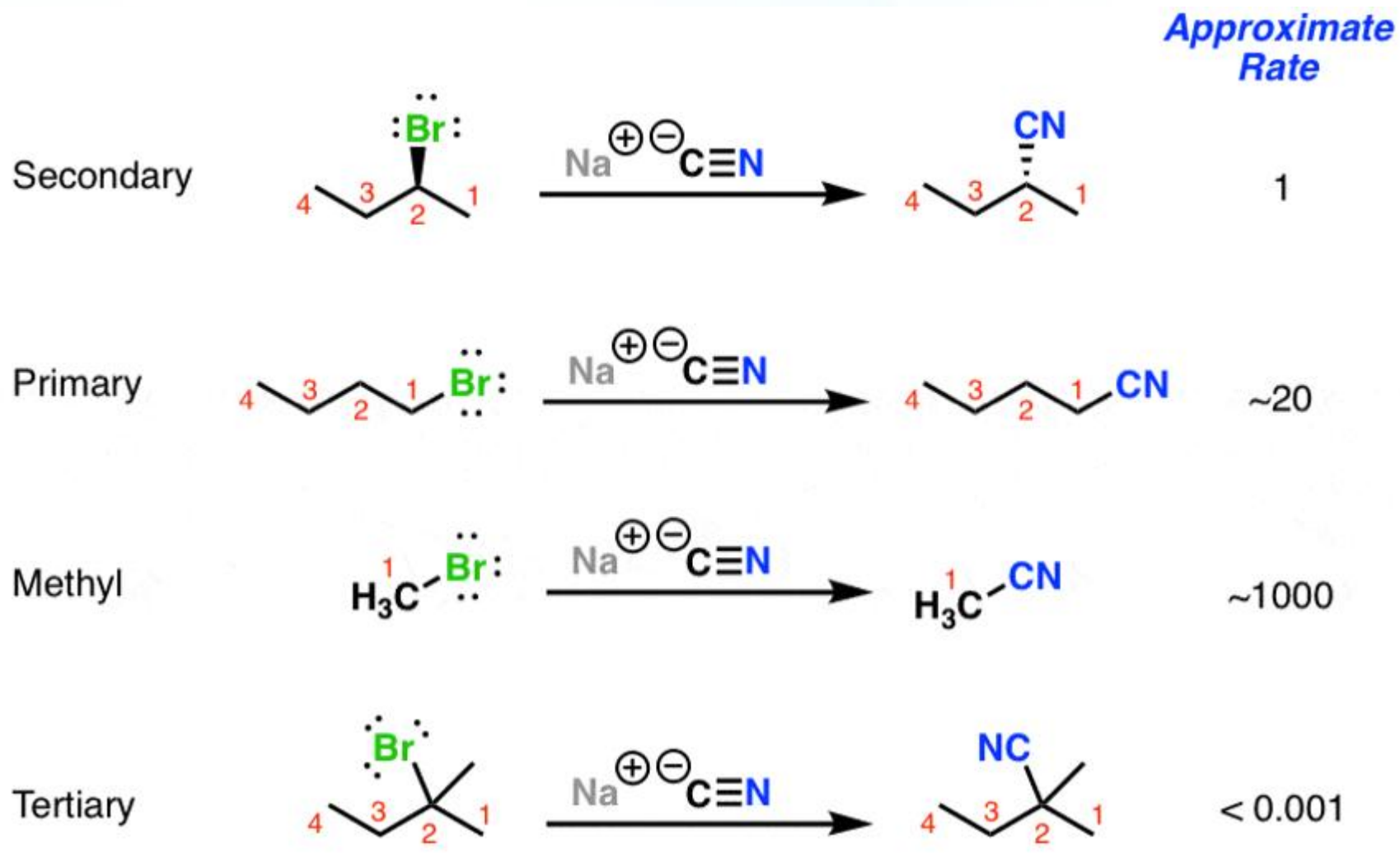




肾上腺素在人体内的合成： S_N2 过程

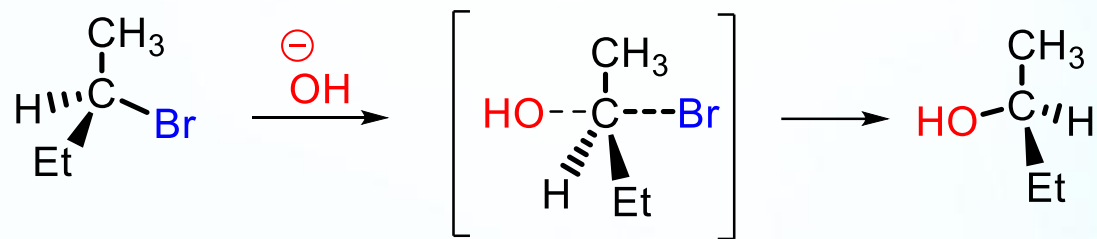


思考题：哪些因素引起了下列反应速率的差别？





◆ 双分子亲核取代反应及反应机理；



鸠占鹊巢

◆ 双分子亲核取代反应特点

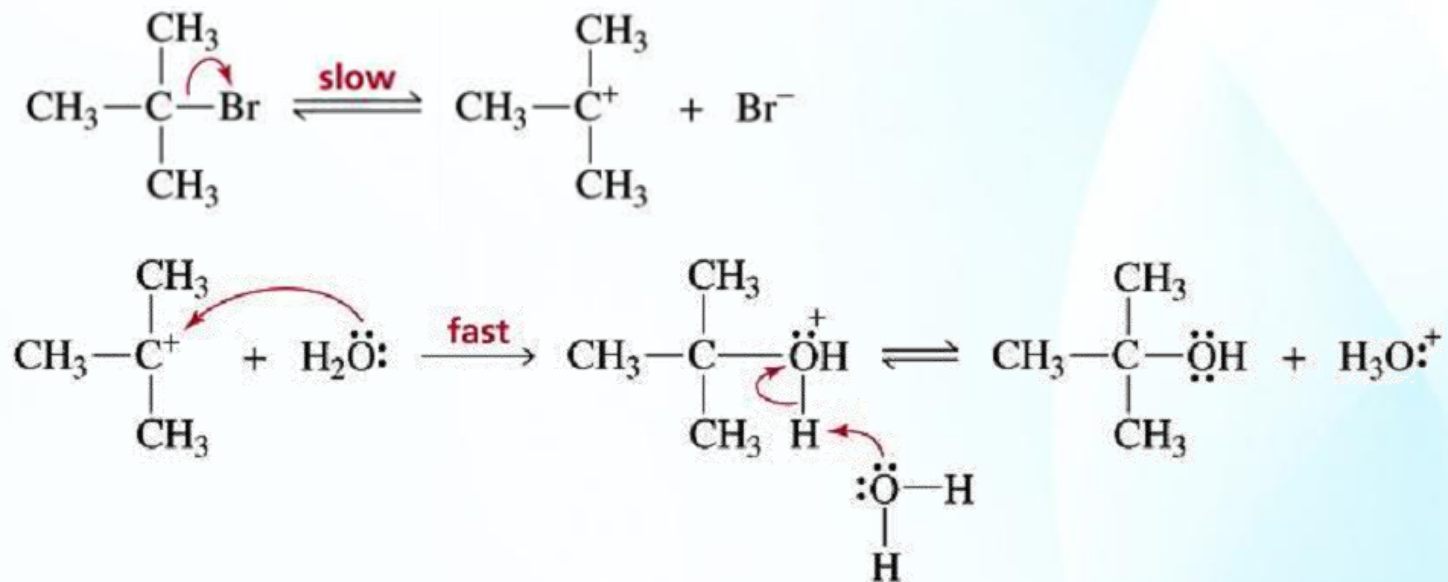
➤ 旧键断裂与新键生成同时进行

✓ 立体化学：构型翻转



卤烷的亲核取代反应历程

单分子亲核取代反应(S_N1): 反应分两步进行, 反应的速度只与反应物的浓度有关, 而与试剂的浓度无关, 反应过程中**有活性中间体-碳正离子生成**

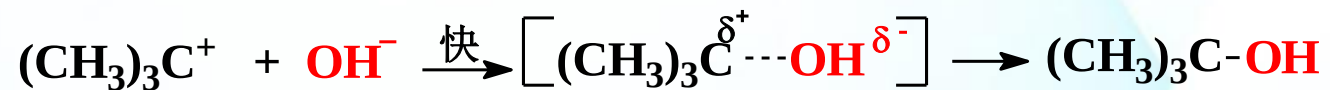
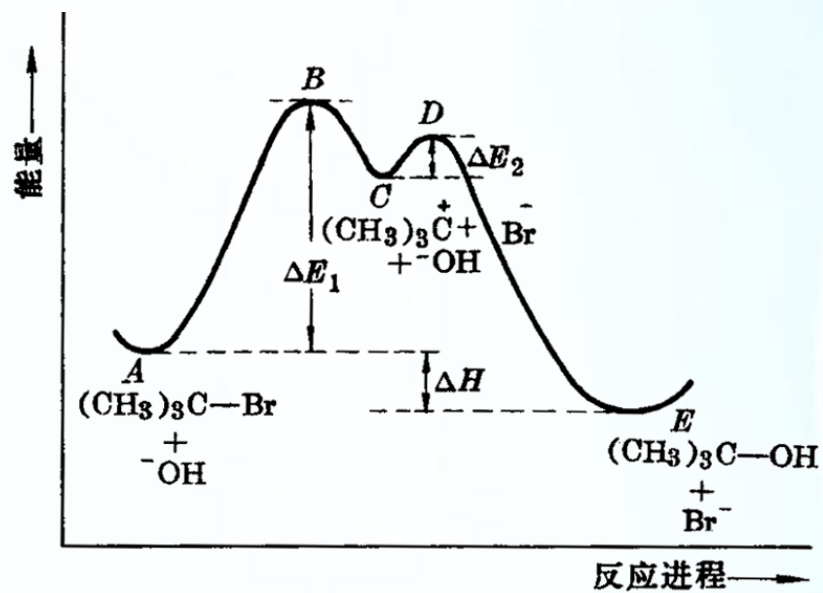


一级反应, $v = k [\text{RX}]$

两步反应, 限速步骤是碳正离子的形成



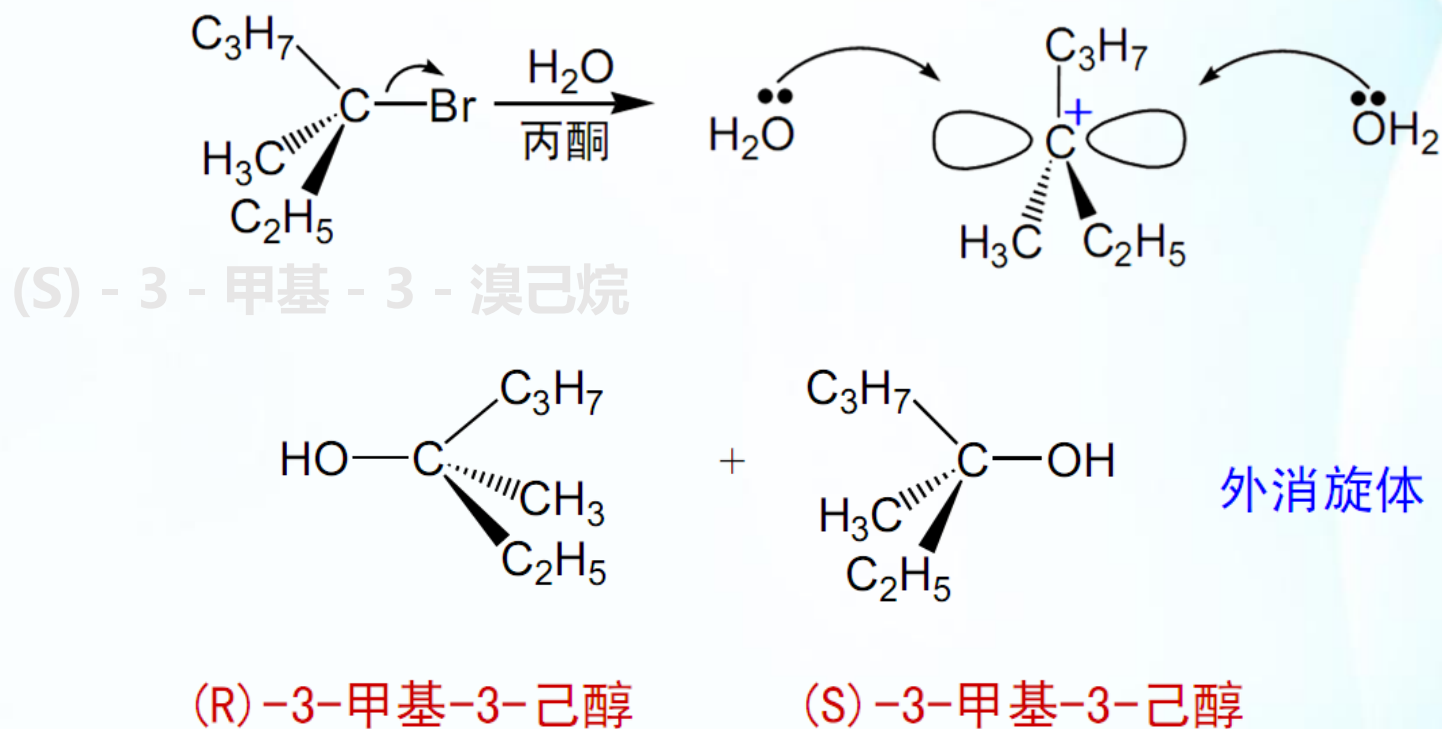
单分子亲核取代反应(S_N1)的势能





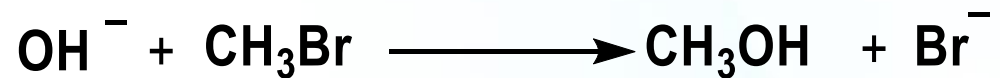
S_N1 反应的立体化学

如果卤素是连在手性碳原子上的卤烷发生 S_N1 水解反应，可得到“构型保持”和“构型转化”几乎等量的两个化合物，即外消旋体混合物（[可以此鉴别历程 \$S_N1\$ 或 \$S_N2\$](#) ）



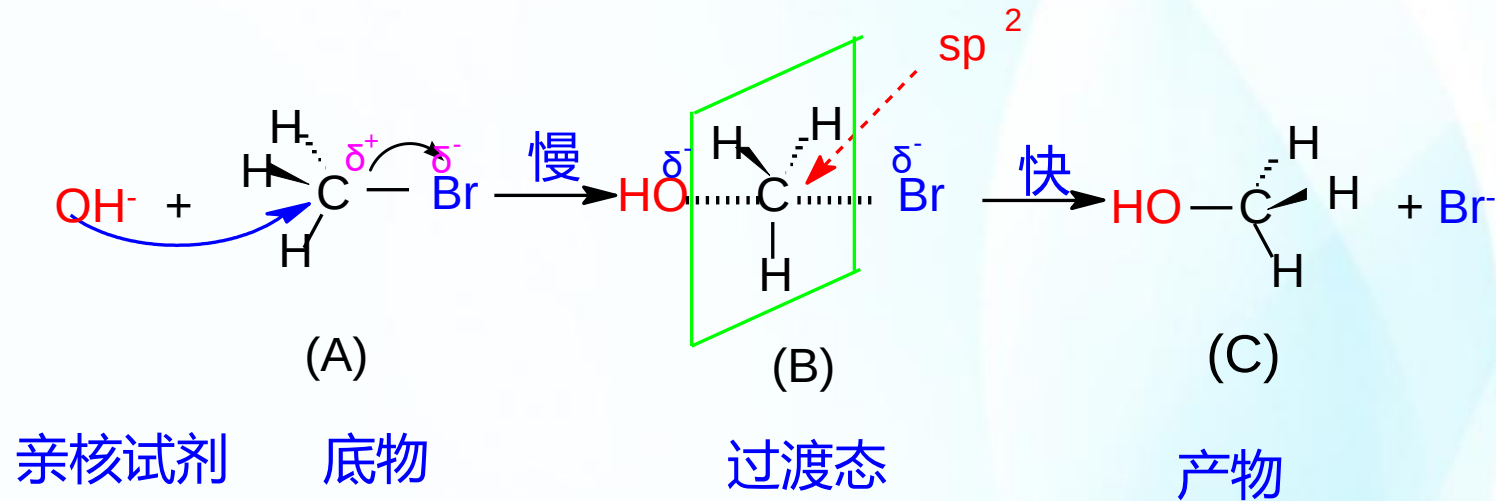


A. Nucleophilic substitution bimolecular (S_N2):



$$v = k[\text{CH}_3\text{Br}][\text{OH}^-]$$

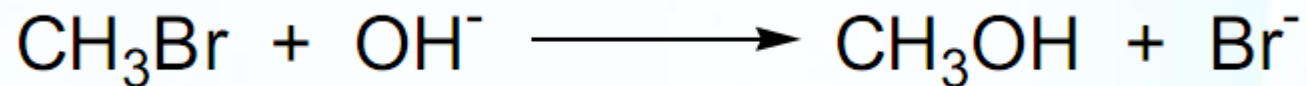
The S_N2 reaction is second order since the rate is dependent both on the alkyl halide and the incoming nucleophile.





卤烷的亲核取代反应历程

双分子亲核取代反应(S_N2): 反应的速度既与反应物的浓度有关, 又与试剂的浓度有关, 反应中新键的生成和旧键的断裂是同步进行的, 共价键的变化发生在两种分子中, 因此是双分子亲核取代反应

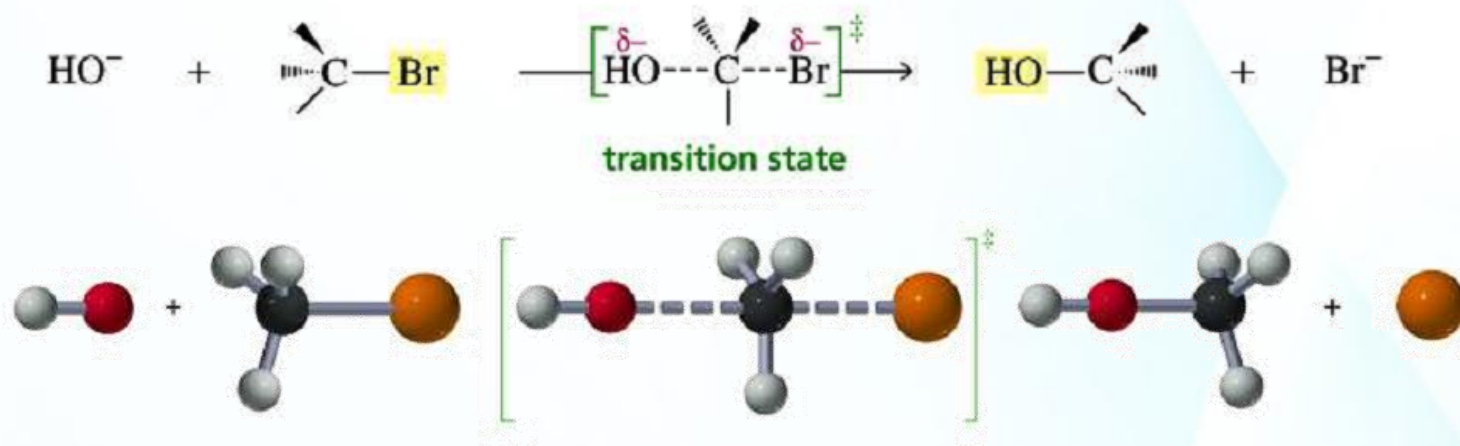


反应速率 $=k[\text{CH}_3\text{Br}][\text{OH}^-]$ **二级反应**



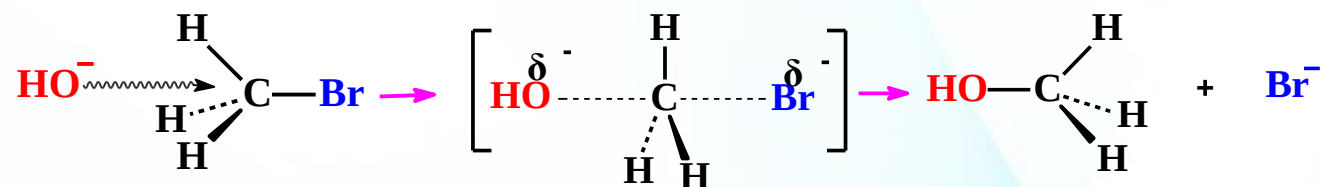
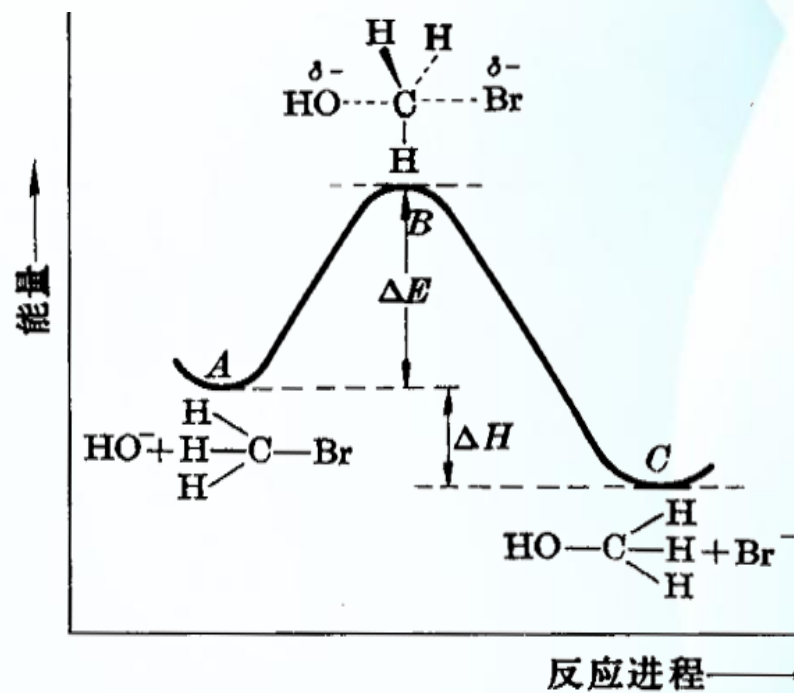
双分子亲核取代反应(S_N2)的历程

瓦尔登转化



一步反应，动力学表现为二级反应

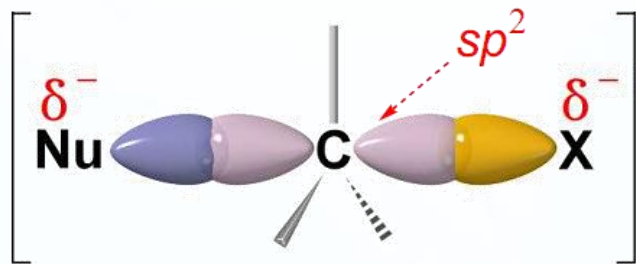
亲核试剂是从离去基团的背面进攻——因此发生构型的转化





双分子亲核取代反应(S_N2)的历程

S_N2反应中过渡态结构



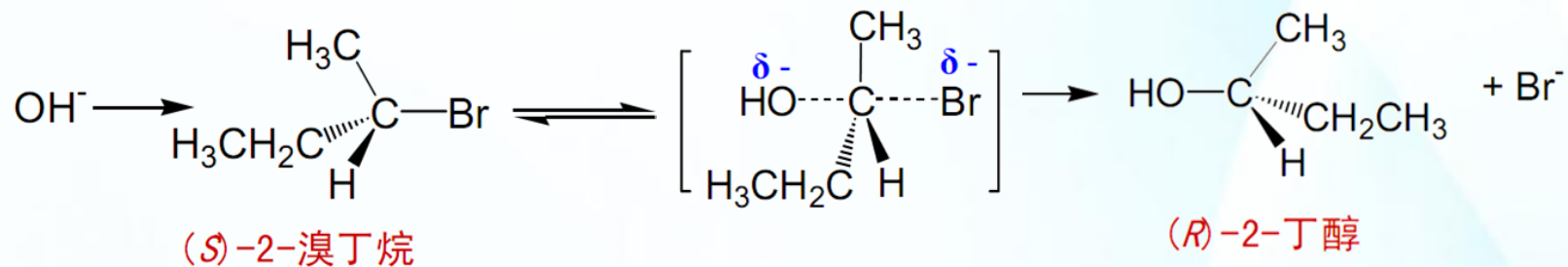
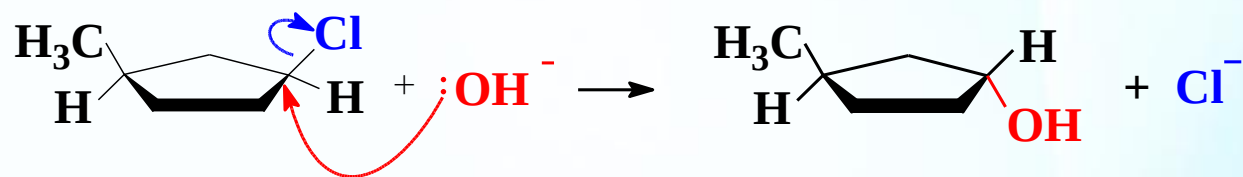
sp²杂化
新键已部分形成
旧键已部分断裂

➤ 旧键断裂和新键生成同时进行



S_N2 反应的立体化学

如果卤素是连在手性碳原子上的卤烷发生 S_N2 水解反应，只得到“构型翻转”的产物



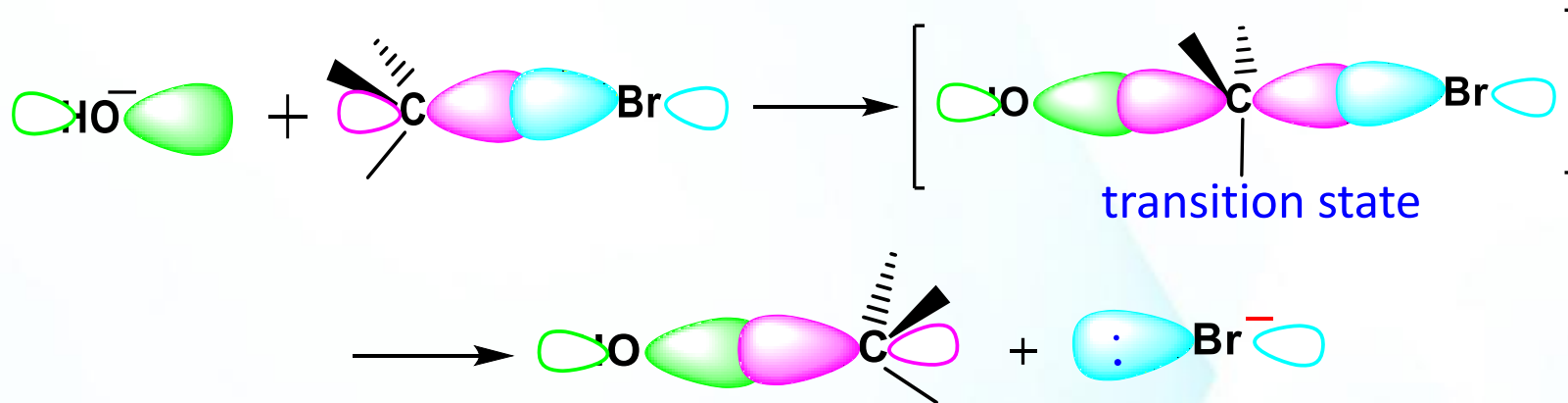


亲核取代反应机理小结

卤代烷亲核取代的两种机理： S_N2 S_N1

- S_N2 机理：双分子取代，一步机理
反应速率 = $k[RX][Nu^-]$
手性底物反应发生构型转换

-
- S_N1 机理：单分子取代，二步机理
反应速率 = $k[RX]$
手性底物反应发生外消旋化



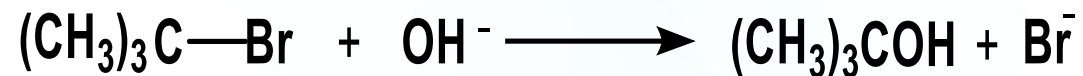
In the transition state for this process, the new bond from the incoming nucleophile is partially formed and the C-X bond is partially broken.

The orbital geometry requires the nucleophiles to be on opposite sides of the molecule.

Primary alkyl halides undergo the S_N2 reaction faster than secondary alkyl halides. Tertiary alkyl halides react extremely slowly if at all.

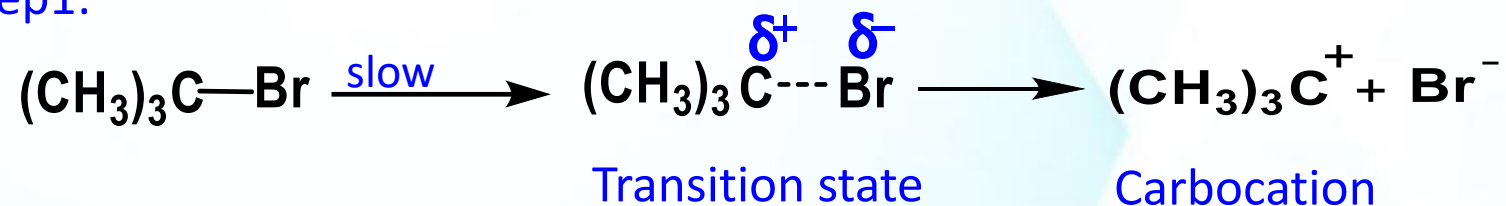


B. Nucleophilic substitution unimolecular (S_N1)

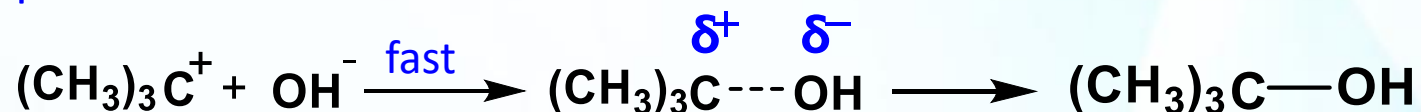


$$v = k [(\text{CH}_3)_3\text{Br}]$$

Step1:



Step2:



The S_N1 mechanism is a two-stage mechanism where the first stage is the rate determining step.

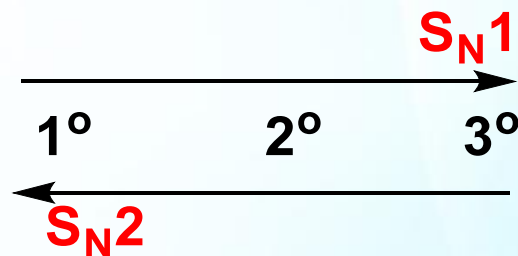
The central carbon of carbocation is now sp^2 hybridized with an empty $2p_y$ orbital.



The nature of the nucleophile, the solvent, and the alkyl halide determine whether nucleophilic substitution takes place by the S_N1 or the S_N2 mechanism.

The reactivity of primary, secondary, and tertiary alkyl halides is controlled by electronic and steric factors.

- ✓ 空间因素： α -C上取代基越多，体积越大 Nu^- 越不易接近 α -C，过渡态也越不稳定；
- ✓ 电子效应： α -C上斥取代基越多， α -C越负，不利于 OH^- 或 Nu^- 进攻 α -C。





The rate of the S_N2 reaction increases with the nucleophilic strength of the incoming nucleophile. The rate of the S_N1 reaction is unaffected by the nature of the nucleophile.

A charged nucleophile is stronger than the corresponding uncharged nucleophile. Nucleophilicity is also related to base strength when the nucleophilic atom is the same.



In polar aprotic solvents, the order of nucleophilic strength for the halides is $F^- > Cl^- > Br^- > I^-$



The reaction rates of both the S_N1 and the S_N2 reaction is increased if the leaving group is a stable ion and a weak base. Iodide is a better leaving group than bromide and bromide is a better leaving group than chloride.

Alkyl fluorides do not undergo nucleophilic substitution.

The better the leaving group, the faster the reaction.

The best leaving groups are the ones which form the most stable anions.

This is also related to basicity in the sense that the more stable the anion, the weaker the base.



C (2.5) F (4.0) Cl (3.0) Br (2.8) I (2.5)

卤代烃: $\text{CH}_3\text{CH}_2\text{-Cl}$ $\text{CH}_3\text{CH}_2\text{-Br}$ $\text{CH}_3\text{CH}_2\text{-I}$ CH_3CH_3
偶极矩 $\mu(\text{D})$: 2.05 2.03 1.91 0

■ Strengths of various bonds (all values in kJ mol^{-1})

C-H = 413

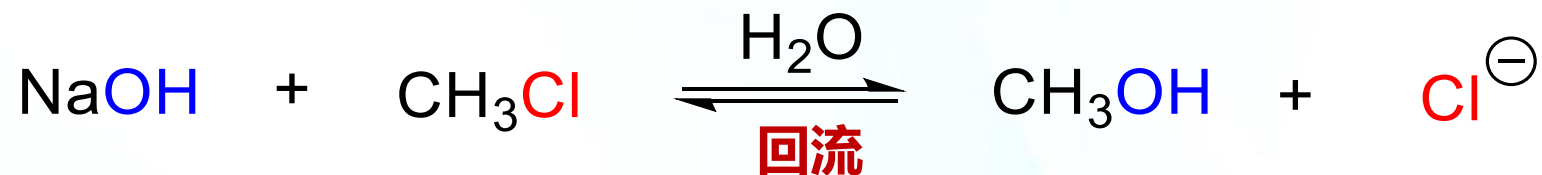
C-F = 467 (very polar, but very strong and difficult to break)

C-Cl = 346

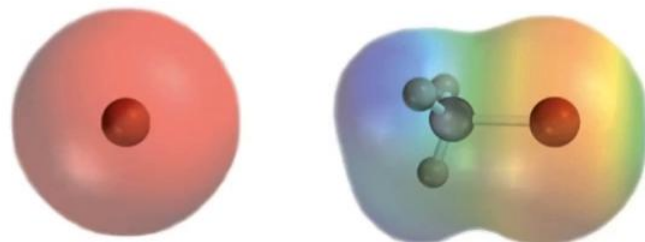
C-Br = 290

C-I = 228 (non polar, but it is polarized in the reaction by
any nucleophile)

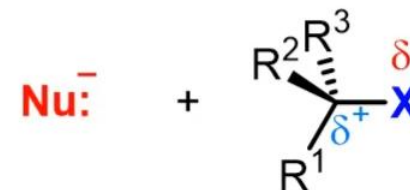
双分子亲核取代反应



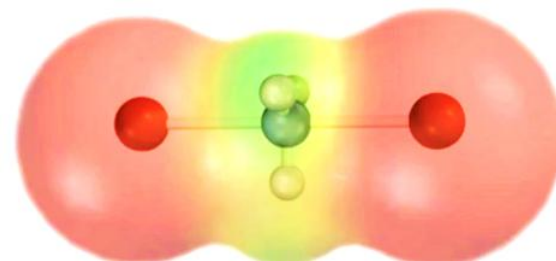
亲核试剂靠近卤代物



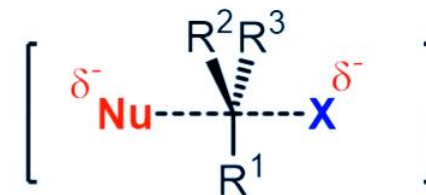
四面体型



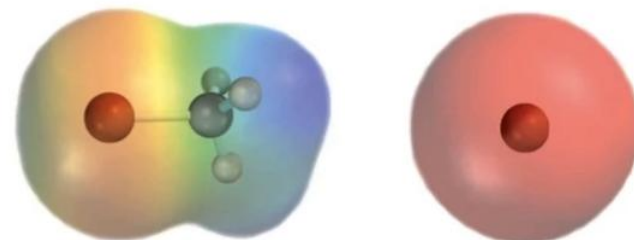
形成双分子过渡态



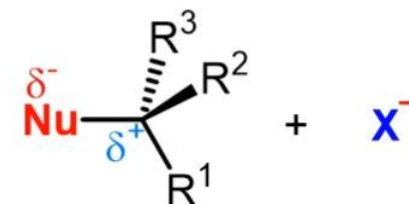
三角双锥



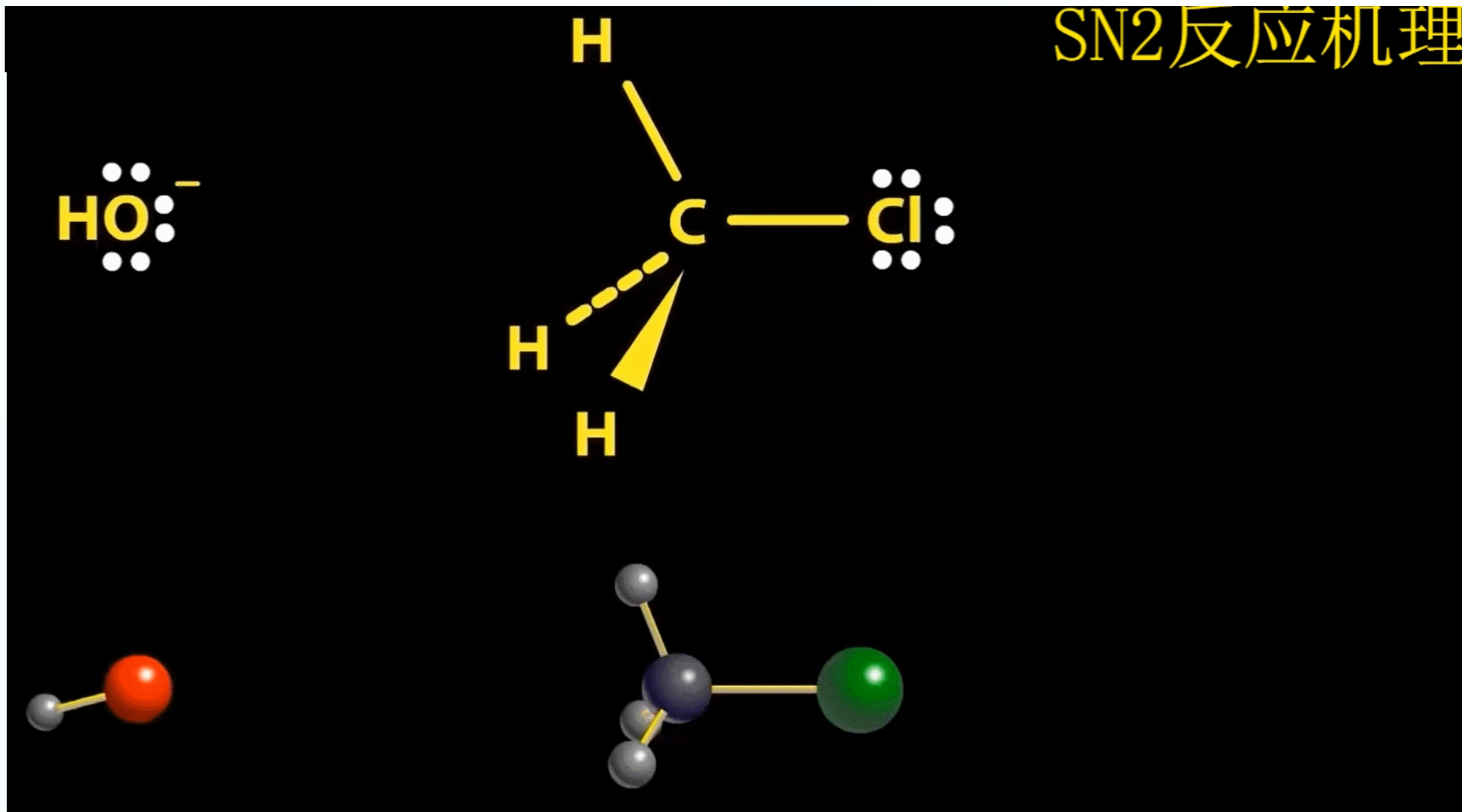
离去基团离开

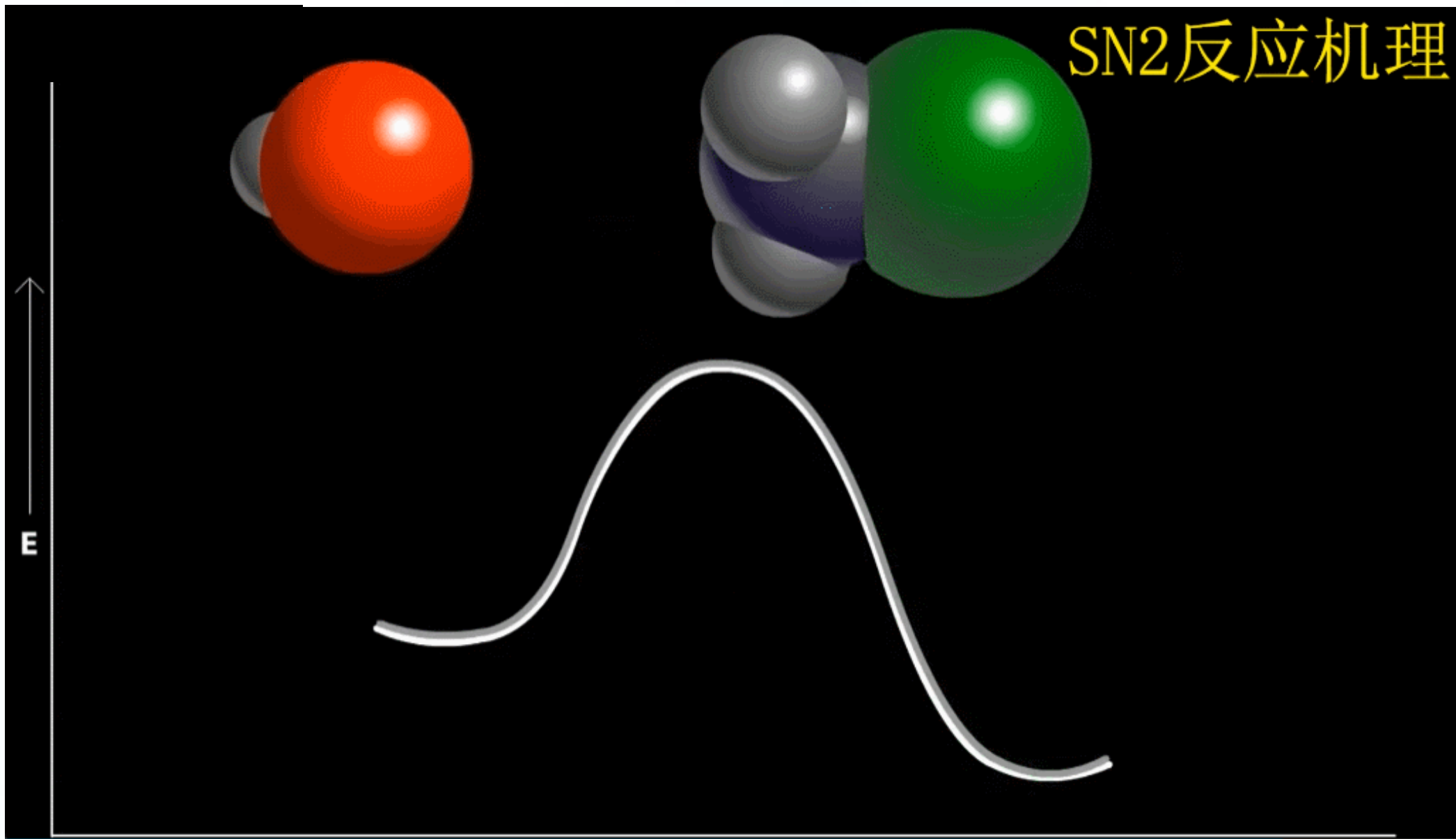


四面体型

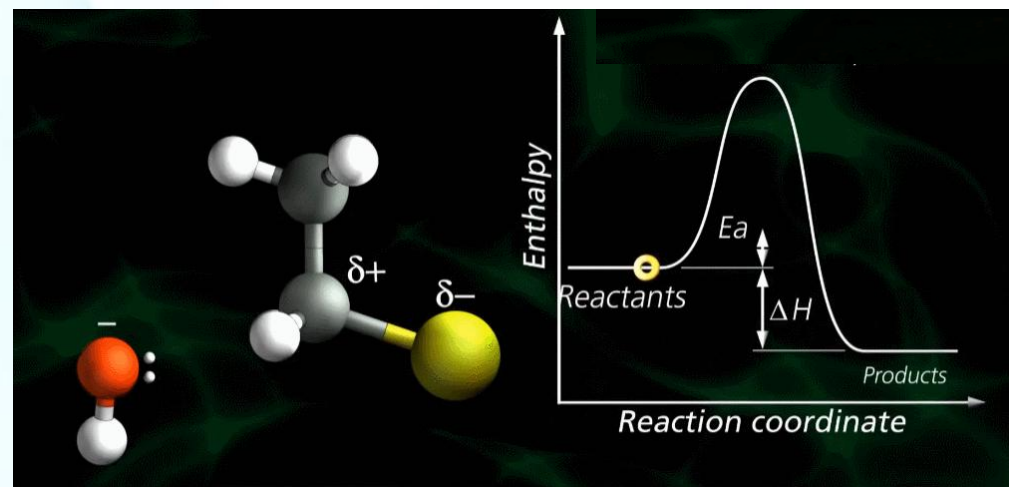
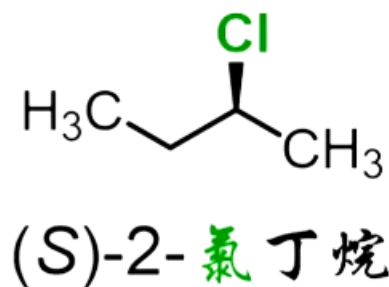
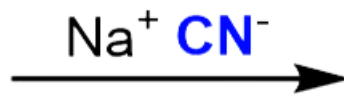
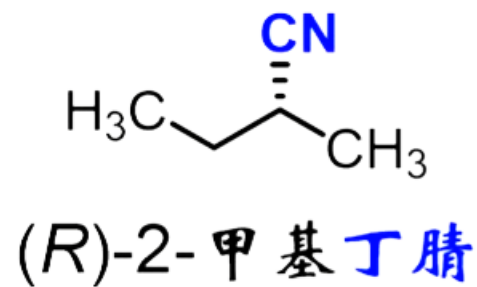


SN2反应机理

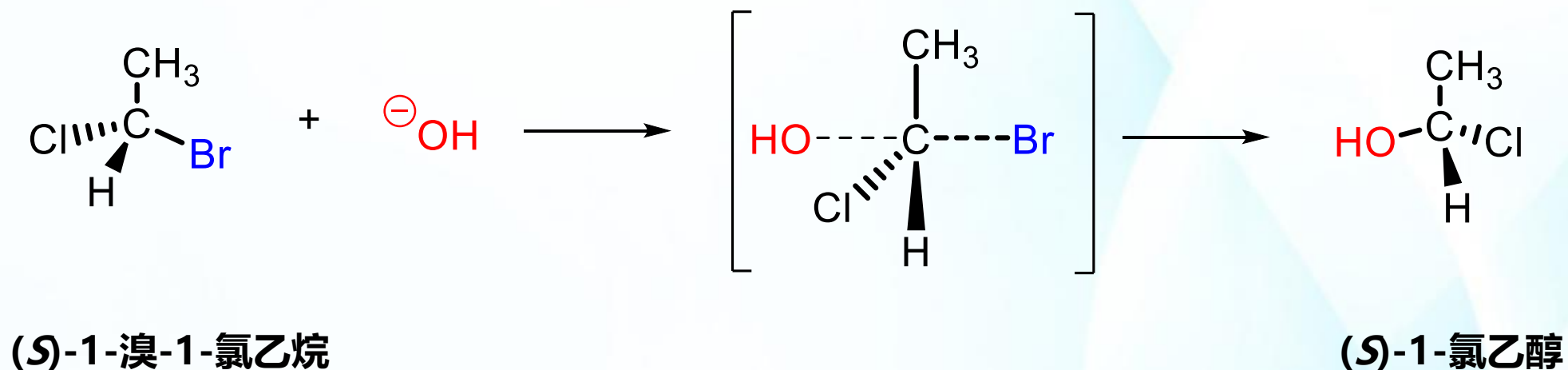




- ✓ **动力学反应特征：一步反应，在动力学上是二级反应**
- ✓ **卤代烃与亲核试剂的浓度都对反应速率产生影响**
- ✓ **亲核试剂从碳-卤键背面进攻（位阻与电子效应影响）**
- **亲核进攻与卤原子离去是协同过程，只有一个过渡态**
- **从手性原料出发，取代后会立体构型发生Walden翻转**



R型的卤代物发生 S_N2 反应之后会变成S型结构？

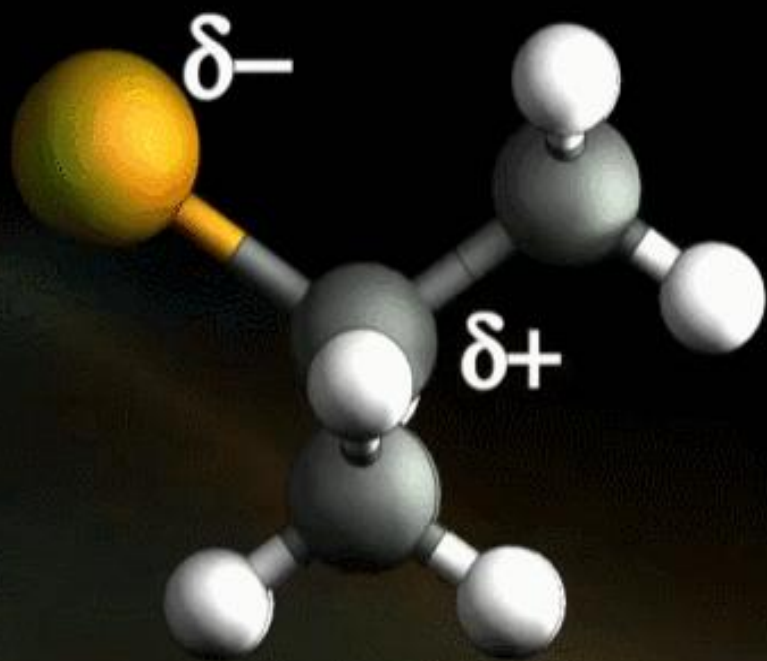
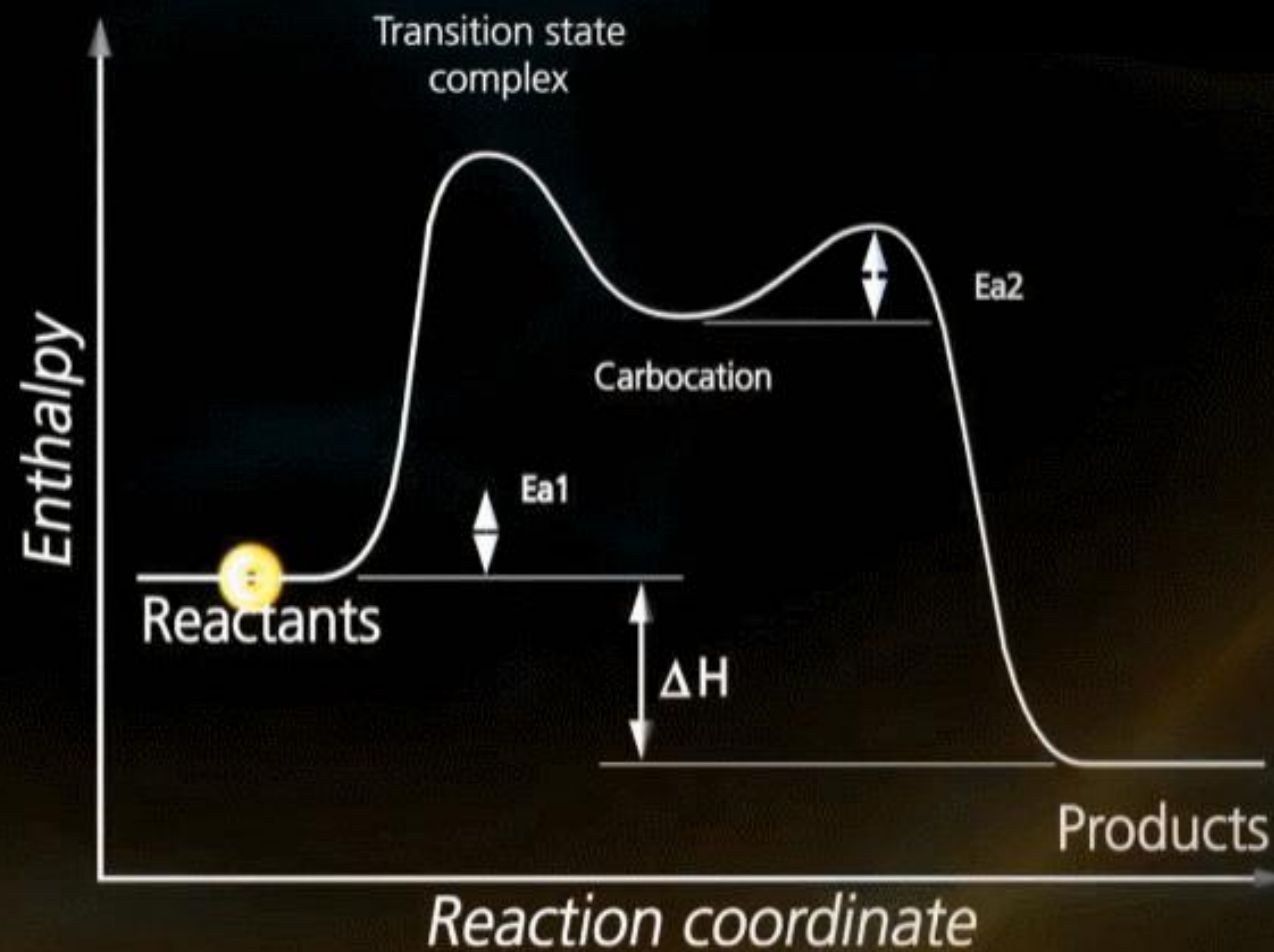


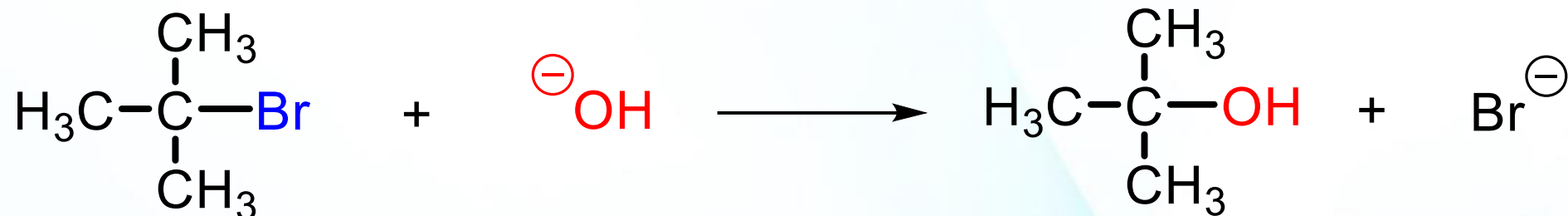
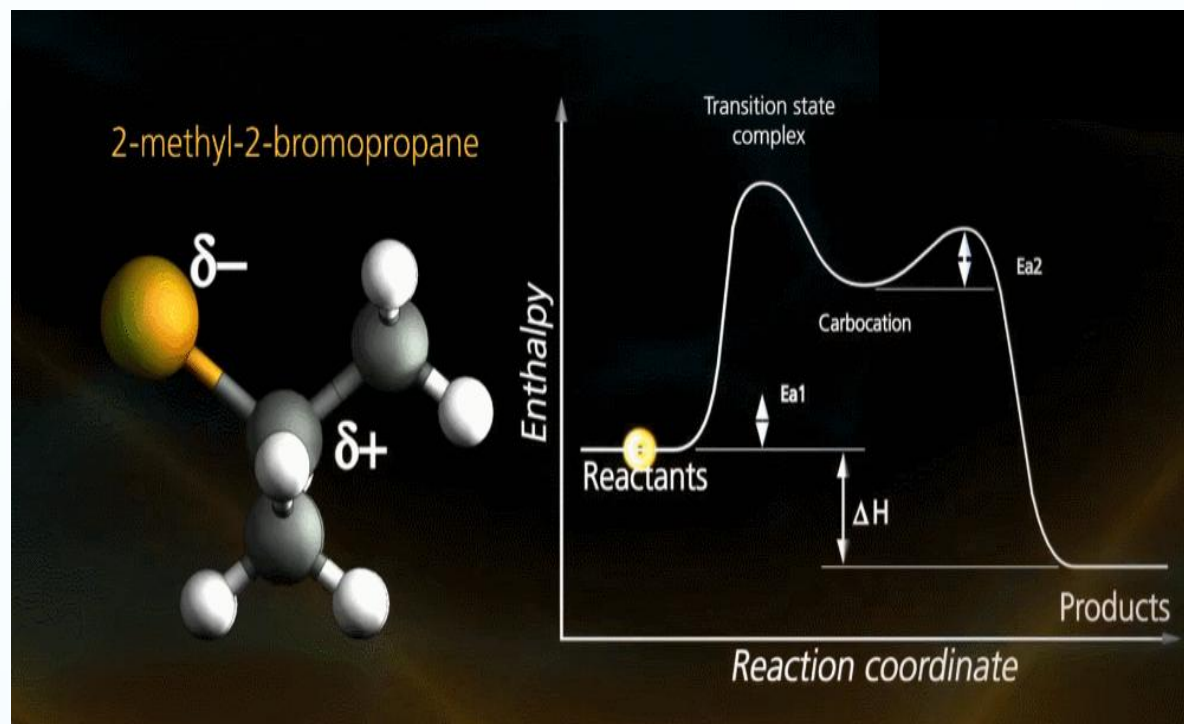
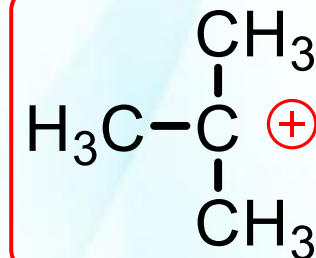
构型翻转不能简单理解成RS的互变！！

客观的空间构型

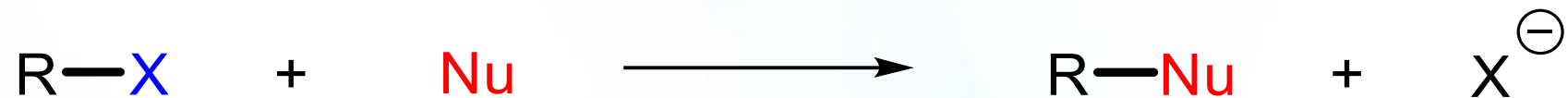
人为规定的基团优先级排序

2-methyl-2-bromopropane



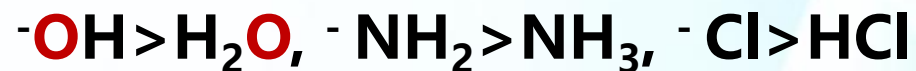


- ◆ 离去基团离开，形成中间体
- ◆ 中间体能量高低影响反应活性
- ◆ 经历一个中间体，两个过渡态，两步反应

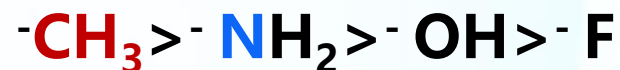


亲核试剂

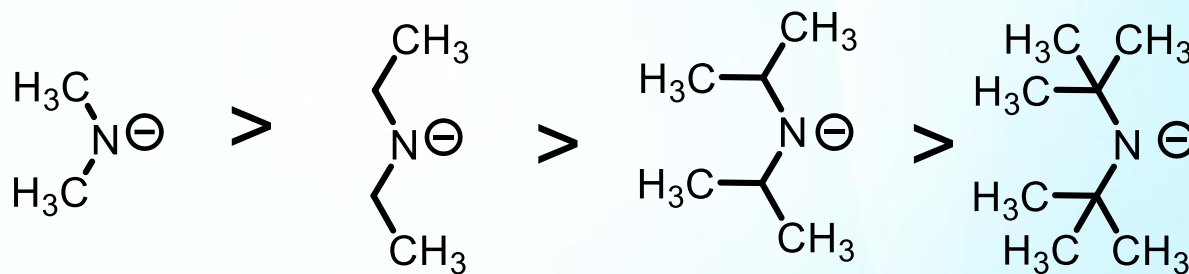
- 离子型亲核试剂活性高于相应的分子



- 亲核试剂本身的电负性



- 空间位阻





离去基团



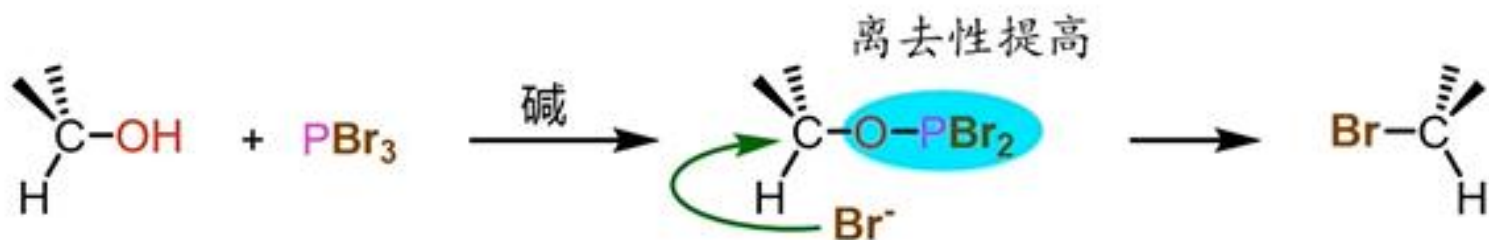
➤ 离去基团的离去性能主要取决于离去之后形成的阴离子的稳定性，越稳定，越易离去

➤ 如果离去基团半径很小或者碱性较强，则不易离去



离去基团	$\text{H}_2\text{N}^-, \text{HO}^-, \text{RO}^-$	F^-	Cl^-	Br^-	I^-	TsO^-
相对反应速率	$\ll 1$	1	200	10,000	30,000	60,000

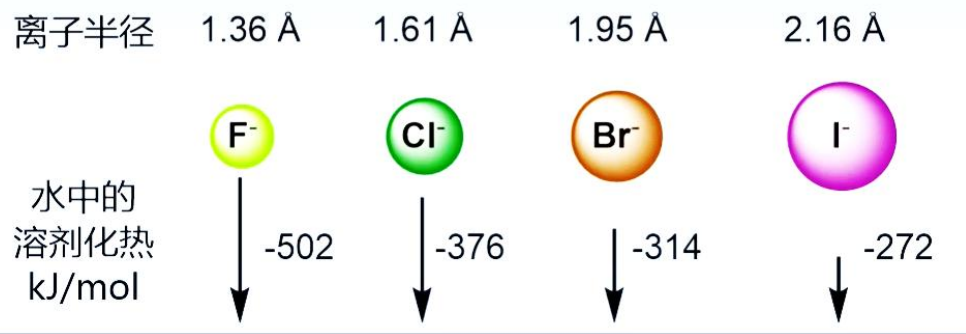
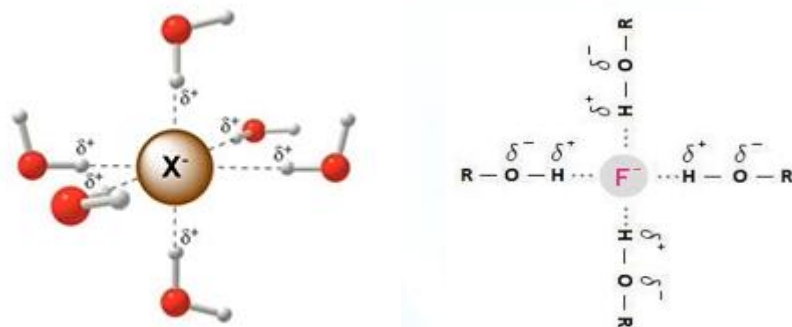
➤ 离去基团的离去性可以调控



溶剂的影响

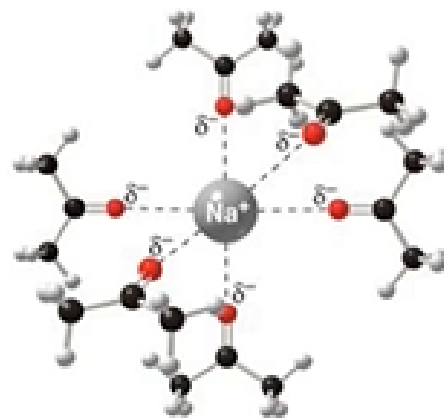


极性质子性溶剂中 (H_2O) :



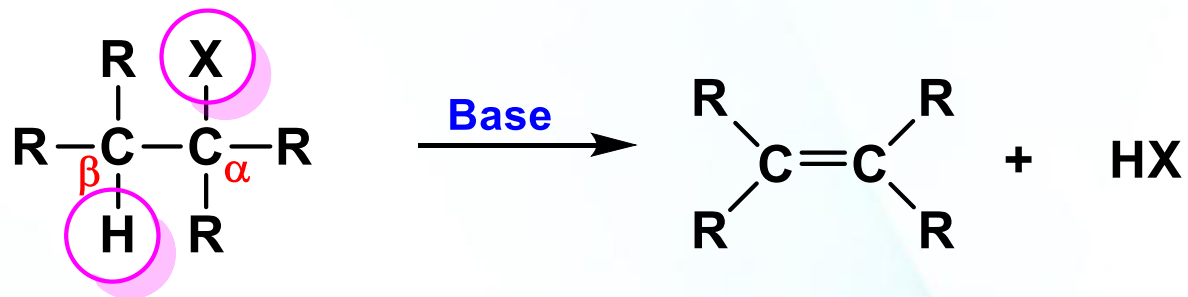
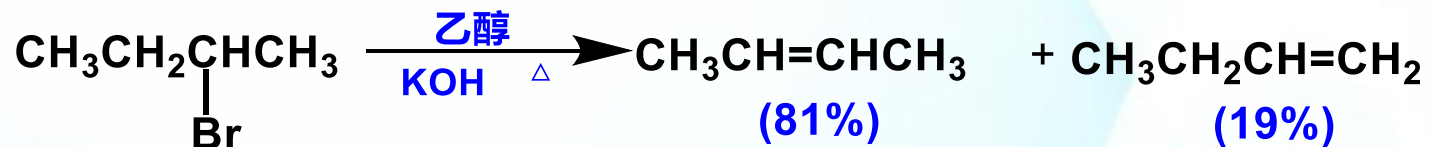
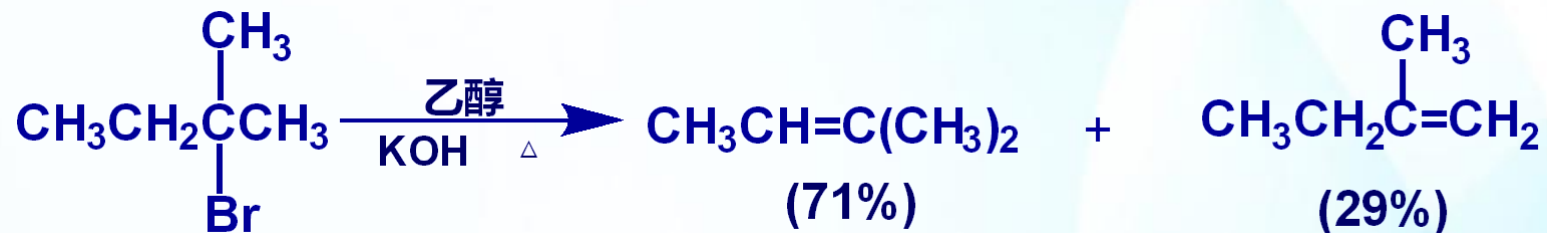
原子半径越小，溶剂化作用越强

- 极性质子性溶剂中，亲核试剂发生溶剂化： $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$
- 极性非质子性溶剂，抗衡阳离子被溶剂化， $\text{F}^- > \text{Cl}^- > \text{Br}^- > \text{I}^-$
负离子本征活性





(2) Elimination

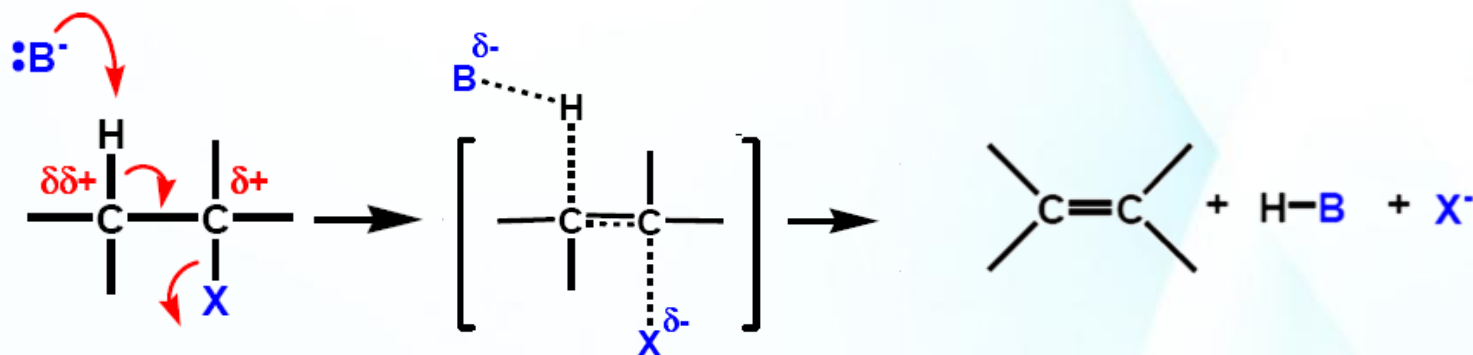


Zaitsev's rule: Eliminations that are regioselective in the direction that yields the alkene with the more substituents. In another word, in the elimination of HX from an alkyl halide, the more highly substituted alkene predominates.



A. Elimination bimolecular (E2):

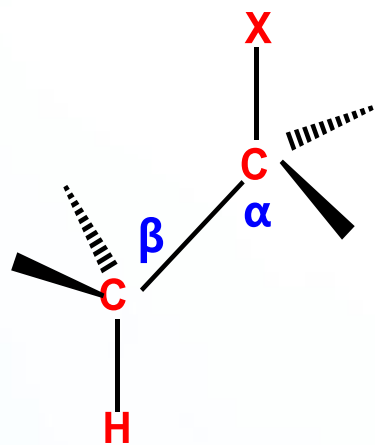
The E2 mechanism is a concerted, one-stage process involving both alkyl halide and nucleophile. The reaction is second order and depends on the concentration of both reactants.



五中心过渡态

旧键的解离与新键的形成同时进行
符合动力学特征 $V = k[\text{RX}][\text{B:}]$

The diagram show that the four atoms involved in the reaction are in a planar with the H and Br on opposite sides of the molecule.

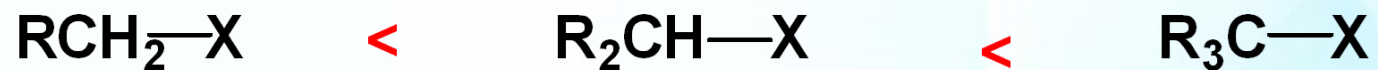


Red atoms are in
one plane



Antiperiplanar
arrangement

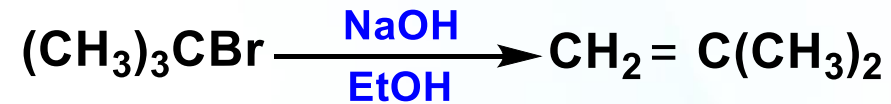
◆ Reactivity of alkyl halides by E2 mechanism



Increasing rate of dehydrohalogenation

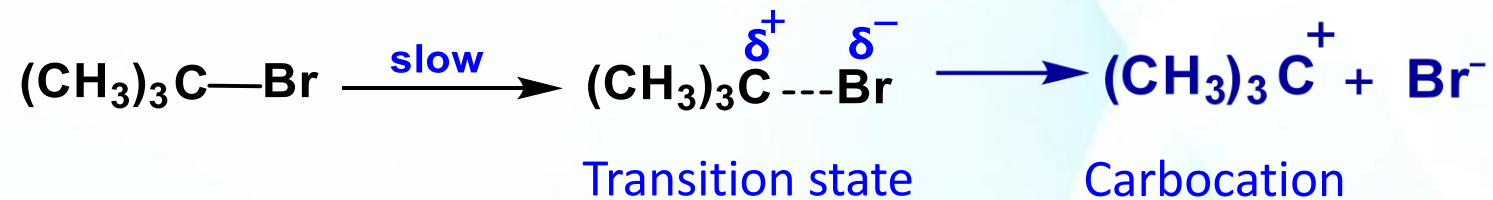


B. Elimination unimolecular (E1):

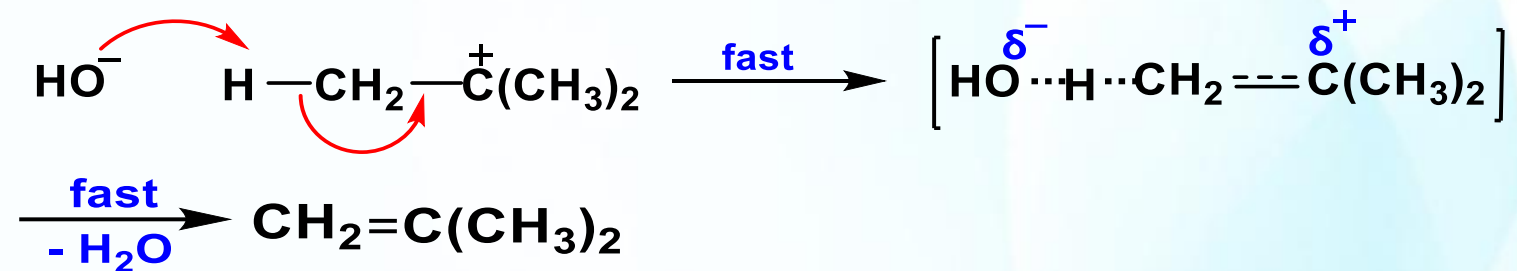


$$v = k[(\text{CH}_3)_3\text{Br}]$$

Step1:

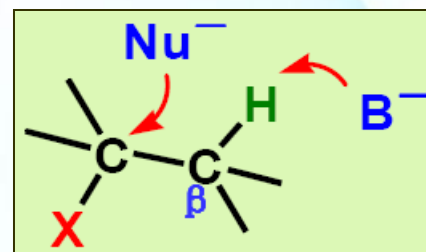
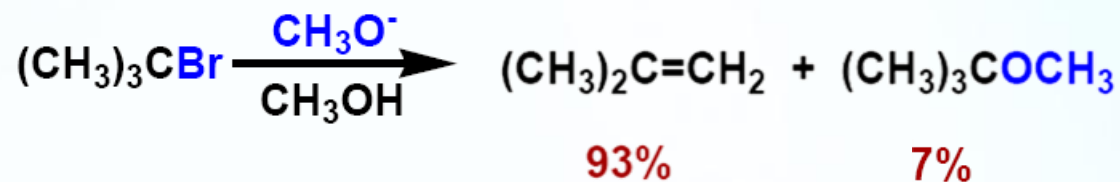


Step2:



The rate determining step is the first stage involving loss of the halide ion.

S_N2与E2: RCH₂X中, R体积增加, E2比例上升, S_N2比例下降

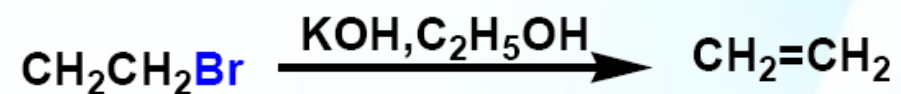
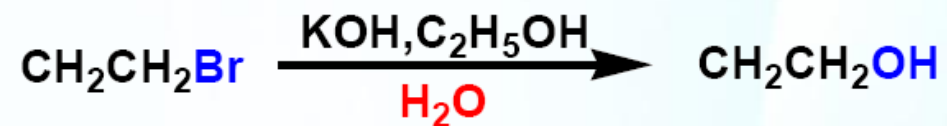




E2与S_N2的竞争

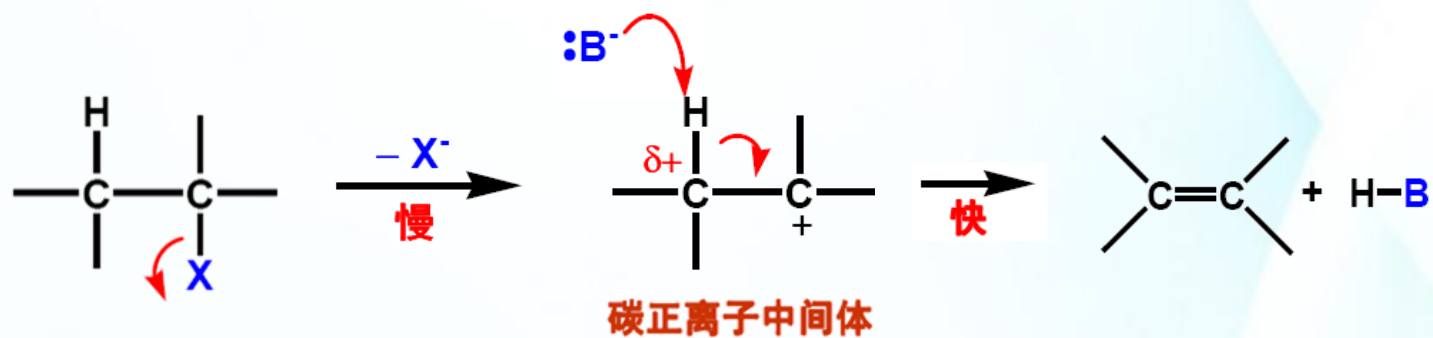
温度：高温有利于消除E2，低温有利于S_N2

溶剂：低极性溶剂对E2有利





单分子消除反应机理(E1)



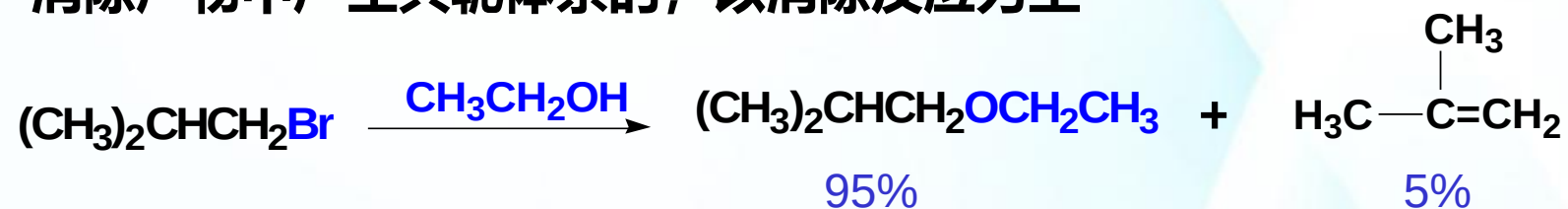
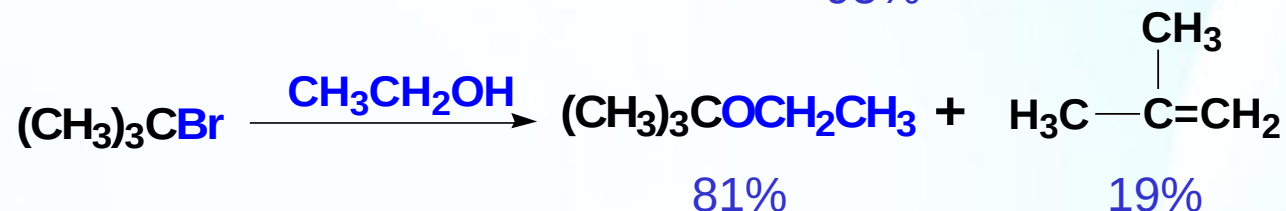
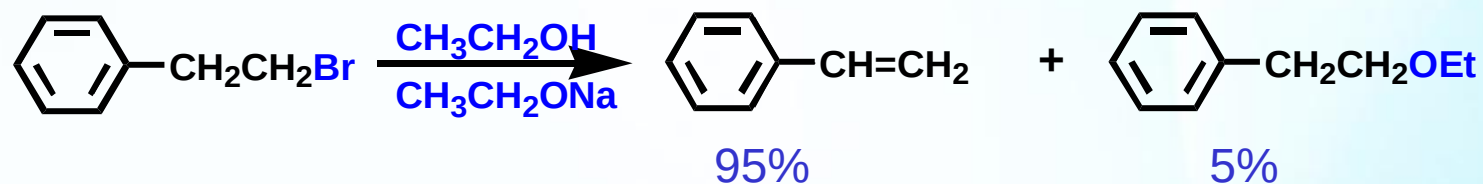
先消除 X^- 再消除 H^+

第一步是决速步骤，符合动力学特征 $V = k[RX]$



E1与S_N1的竞争

- 无碱时，为S_N1与E1反应，以S_N1为主
- α-C上烷基多或β-C上支链多，E1比例上升
- 消除产物中产生共轭体系的，以消除反应为主



S_N1与E1: 高温对E1有利



◆ Reactivity of alkyl halides by E1 mechanism



Increasing rate of dehydrohalogenation, depending on
the stability of carboncation

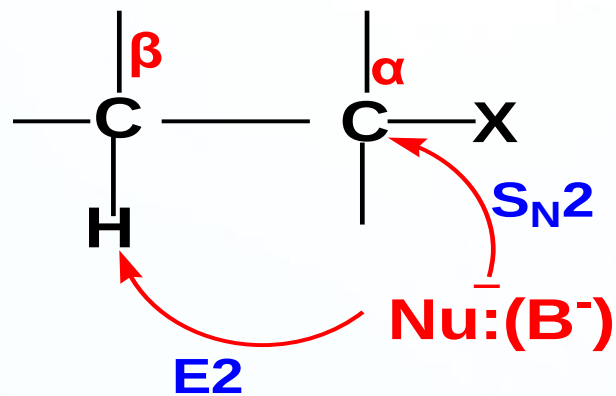
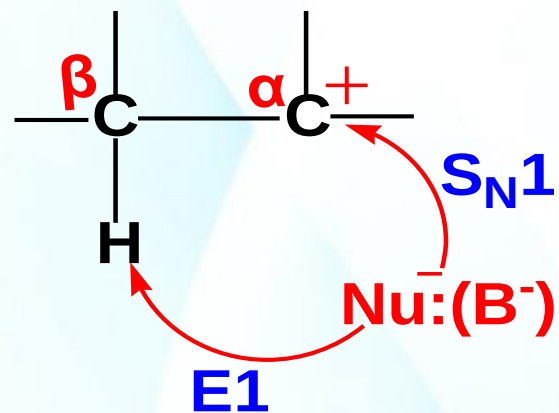
A mixture of isomers may be obtained with the more stable (more substituted) alkene being favored.

These are the same conditions for the S_N1 reaction and so both these reactions usually occur at the same time resulting in a mixture of products.



(3) Elimination versus Substitution

反应产物常受卤代烃的结构、试剂的亲核性强弱、试剂的碱性强弱、试剂的体积大小及反应的温度等多种因素共同影响和控制。

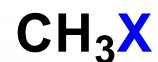


相互竞争!

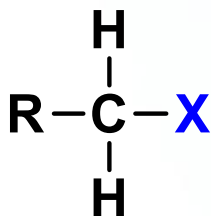
反应温度高更有利于消除 (需断裂 C-H 和 C-X) ;
反应温度低有利于取代 (只断 C-X) 。



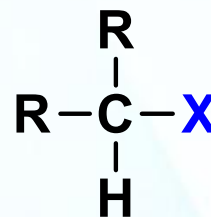
S_N1 , S_N2 , E1, and E2 reactions



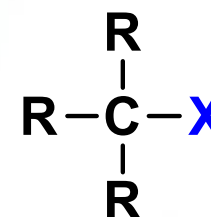
Methyl



1°



2°



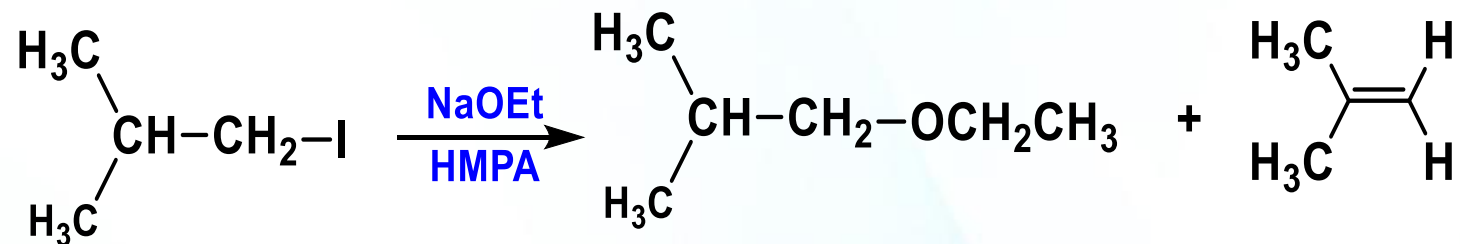
3°

Gives S_N2 reactions

Gives mainly S_N2 except with a **hindered strong base** $[(\text{CH}_3)_3\text{CO}^-]$ and then gives mainly E2.

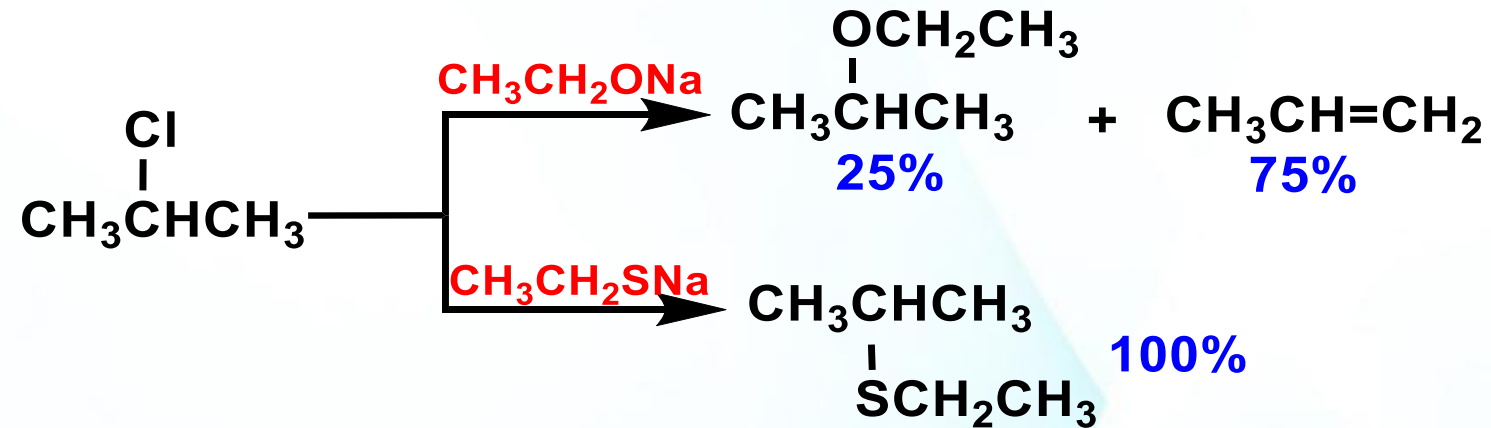
Gives mainly S_N2 with **Weak base** $[\text{I}^-, \text{RCO}_2^-]$ and mainly E2 with **strong bases** (RO^-) .

No S_N2 reaction. In **solvolysis** gives $S_N1/\text{E1}$, and **at low temperatures** S_N1 is favored. **When** a strong bases (RO^-) is used, E2 predominate.

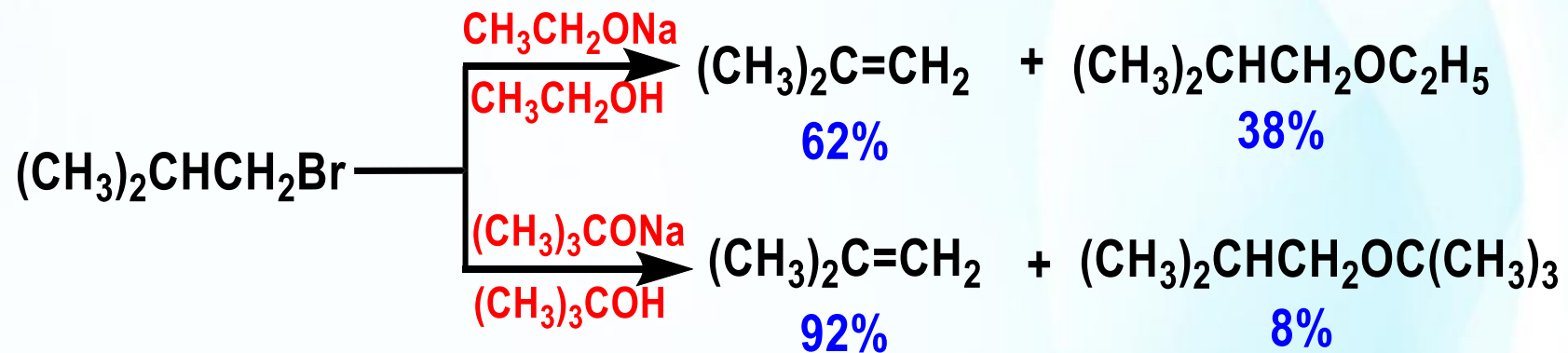


Treatment of a primary halide with an ethoxide ion is likely to give a mixture of an ether arising from $\text{S}_{\text{N}}2$ substitution along with an alkene arising from E2 elimination, with the ether being favored. By using sodium tert-butoxide instead, the preferences would be reversed.

Increasing the temperature of the reaction shifts the balance from the $\text{S}_{\text{N}}2$ reaction to the E_2 elimination. This is because the elimination reaction has a higher activation energy due to more bonds being broken.



碱性： $\text{CH}_3\text{CH}_2\text{O}^- > \text{CH}_3\text{CH}_2\text{S}^-$ ； 亲核性： $\text{CH}_3\text{CH}_2\text{S}^- > \text{CH}_3\text{CH}_2\text{O}^-$



亲核性强，有利 $\text{S}_\text{N}2$ ； 碱性强、体积大，有利 $\text{E}2$ 。



Summary

1. 卤代烃的命名;
2. 卤代烃的结构特点;
3. 卤代烃的化学反应

亲核取代反应: S_N1 S_N2

消除反应: $E1$ $E2$

亲核取代反应与消除反应的竞争。



作业:

P231 7.9

P232 7.15 7.17 7.18 7.19 7.20

P233 7.22

P235 7.36(a)(d)

P236 7.43



也许有一天，不知不觉，你将渐渐活出写满答案的人生！