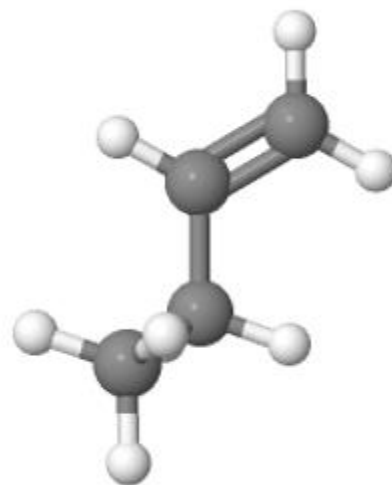


Alkenes – Properties and Preparations



Instructor: Asst. Prof. Dr. Tanatorn Khotavivattana

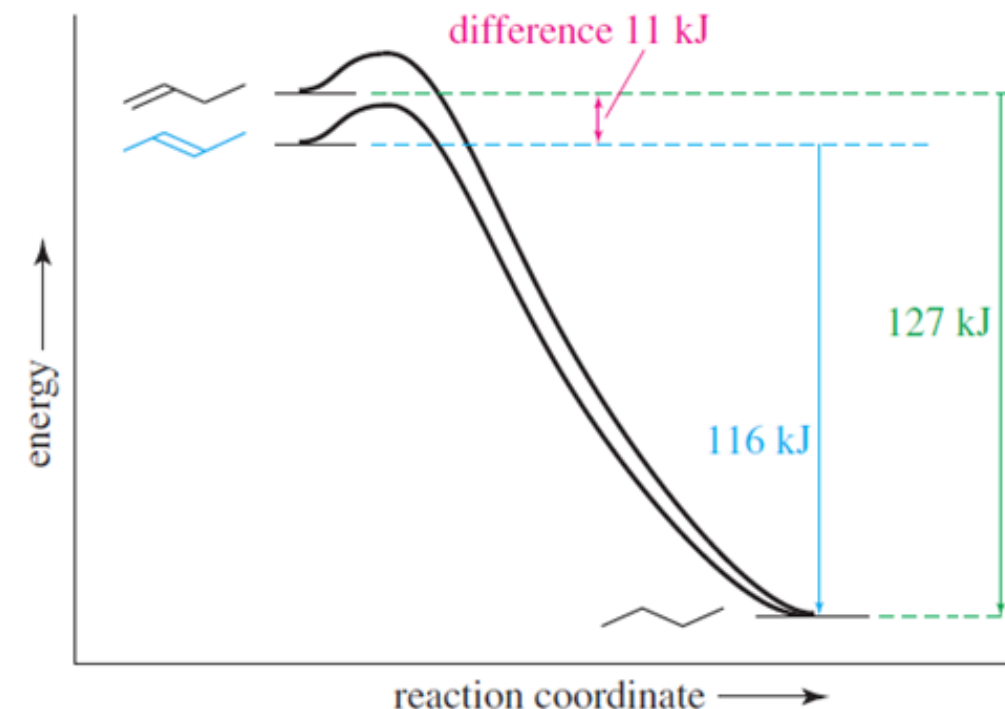
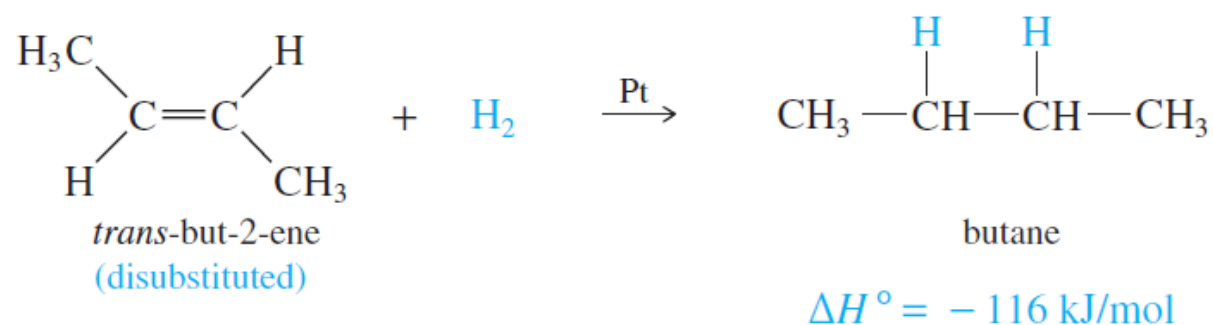
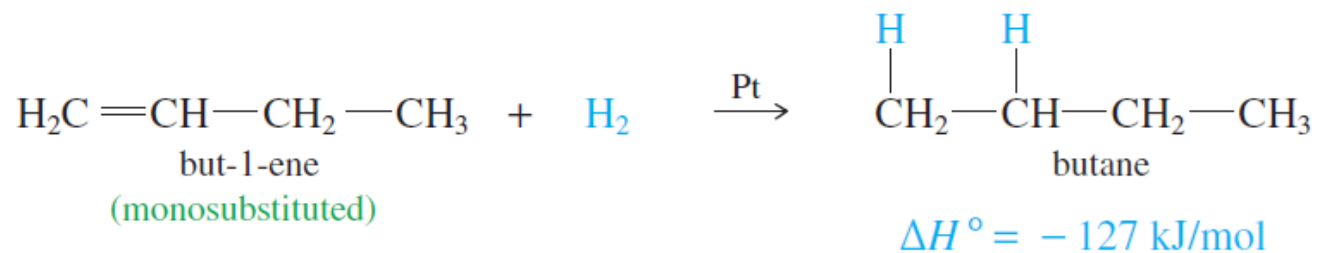
E-mail: tanatorn.k@chula.ac.th

Recommended Textbook:

Chapter 7 in *Organic Chemistry*, 8th Edition, L. G. Wade, Jr., 2010, Prentice Hall (Pearson Education)

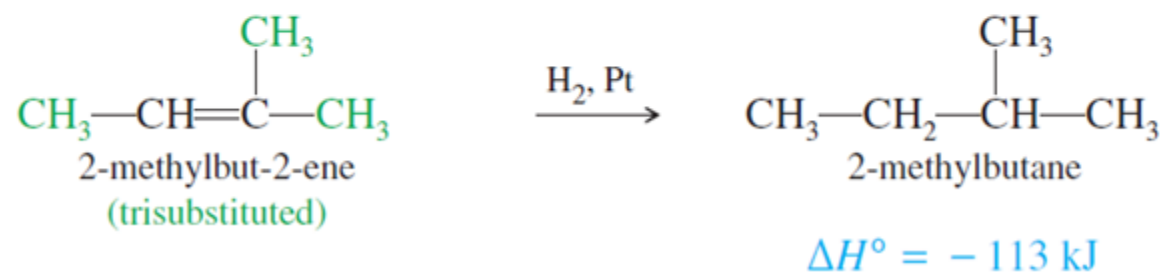
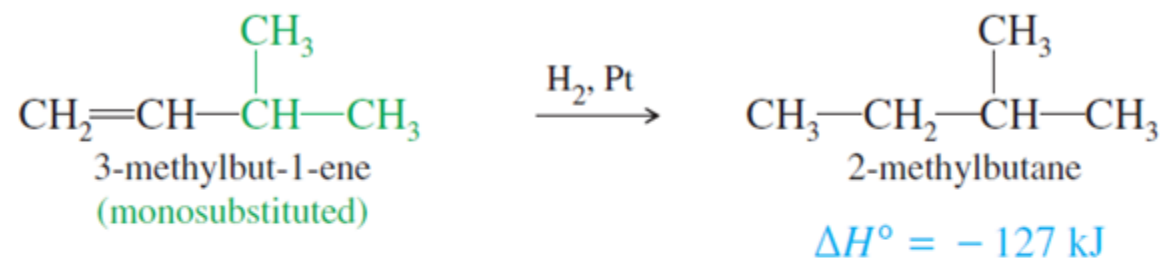
Stability of Alkenes

Alkene energies are often compared by measuring the **heat of hydrogenation**: the heat given off (ΔH°) during catalytic hydrogenation.

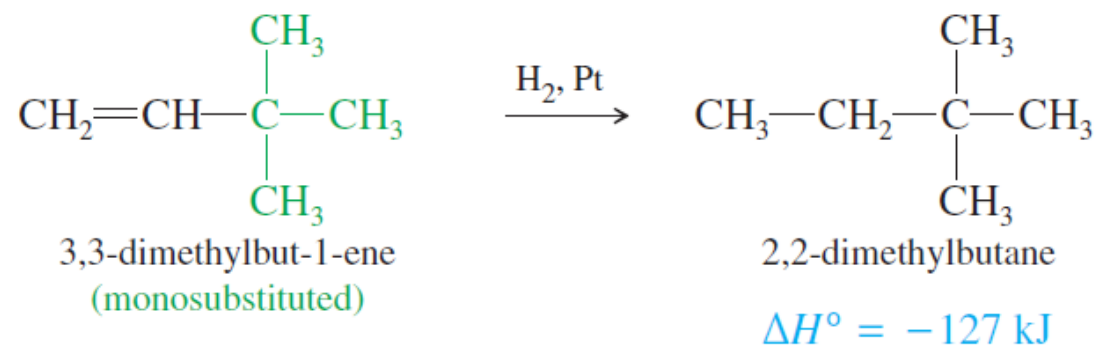


Stability: Disubstituted > Monosubstituted (11 kJ/mol)

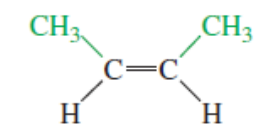
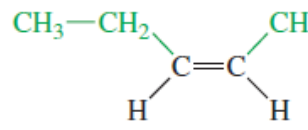
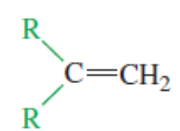
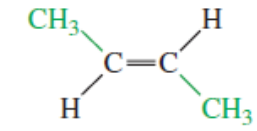
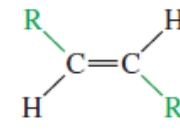
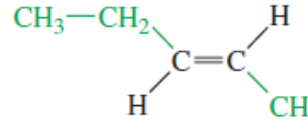
Stability of Alkenes



Stability: Trisubstituted > Monosubstituted (16 kJ/mol)



Stability of Alkenes

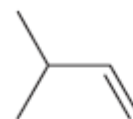
Name	Structure	Molar Heat of Hydrogenation ($-\Delta H^\circ$)		General Structure
		kJ	kcal	
ethene (ethylene)	$\text{H}_2\text{C}=\text{CH}_2$	137	32.8	unsubstituted
propene (propylene)	$\text{CH}_3-\text{CH}=\text{CH}_2$	126	30.1	monosubstituted $\text{R}-\text{CH}=\text{CH}_2$
but-1-ene	$\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}_2$	127	30.3	
pent-1-ene	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}=\text{CH}_2$	126	30.1	
hex-1-ene	$\text{CH}_3-(\text{CH}_2)_3-\text{CH}=\text{CH}_2$	126	30.1	
3-methylbut-1-ene	$(\text{CH}_3)_2\text{CH}-\text{CH}=\text{CH}_2$	127	30.3	
3,3-dimethylbut-1-ene	$(\text{CH}_3)_3\text{C}-\text{CH}=\text{CH}_2$	127	30.3	
<i>cis</i> -but-2-ene		120	28.6	
<i>cis</i> -pent-2-ene		120	28.6	
2-methylpropene (isobutylene)	$(\text{CH}_3)_2\text{C}=\text{CH}_2$	117	28.0	disubstituted (<i>geminal</i>) 
2-methylbut-1-ene	$\text{CH}_3-\text{CH}_2-\underset{\text{CH}_3}{\text{C}}=\text{CH}_2$	119	28.5	
2,3-dimethylbut-1-ene	$(\text{CH}_3)_2\text{CH}-\underset{\text{CH}_3}{\text{C}}=\text{CH}_2$	117	28.0	
<i>trans</i> -but-2-ene		116	27.6	disubstituted (<i>trans</i>) 
<i>trans</i> -pent-2-ene		116	27.6	
2-methylbut-2-ene	$\text{CH}_3-\underset{\text{CH}_3}{\text{C}}=\text{CH}-\text{CH}_3$	113	26.9	trisubstituted $\text{R}_2\text{C}=\text{CHR}$
2,3-dimethylbut-2-ene	$(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2$	111	26.6	tetrasubstituted $\text{R}_2\text{C}=\text{CR}_2$



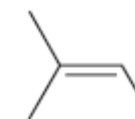
More substituted double bonds are usually more stable.

1) Electronic

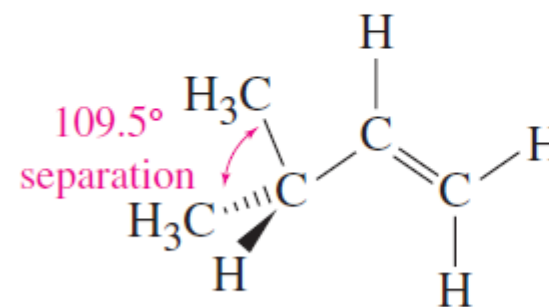
2) Steric



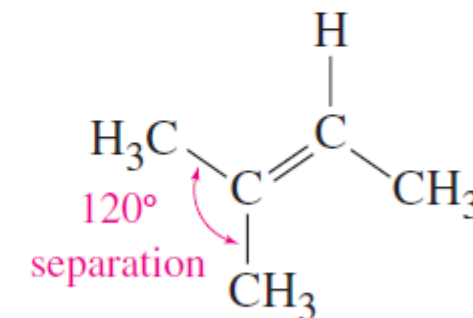
less substituted



more substituted



closer groups

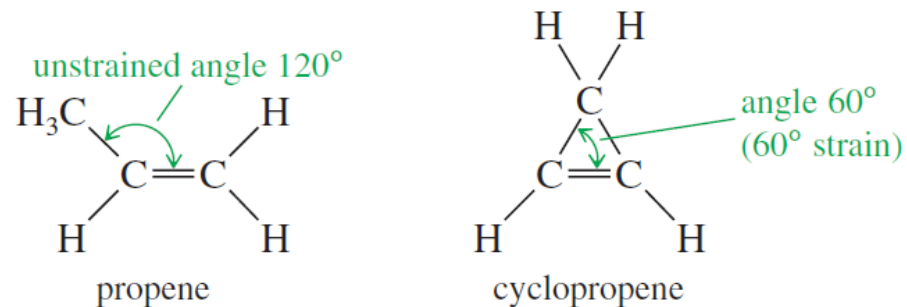
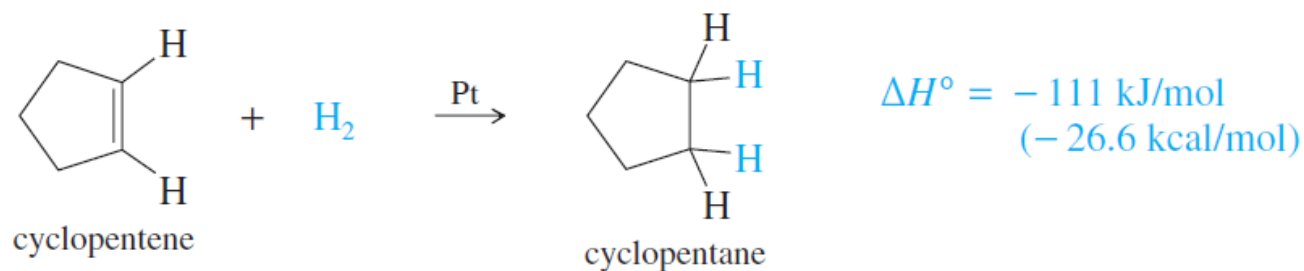
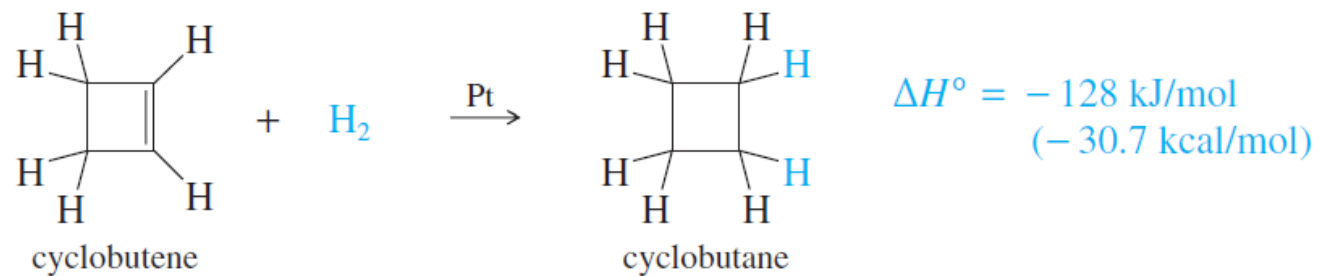


wider separation

Stability of Cycloalkenes

Most cycloalkenes react like acyclic (noncyclic) alkenes.

3 and **4**-membered rings show evidence of **ring strain**

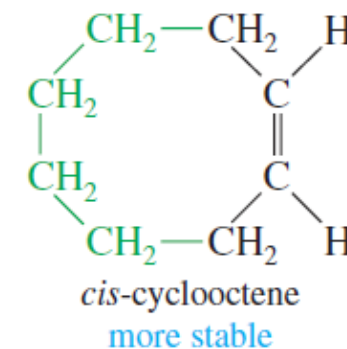
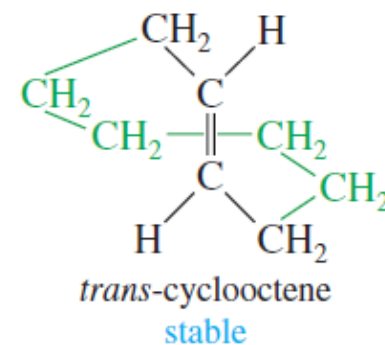
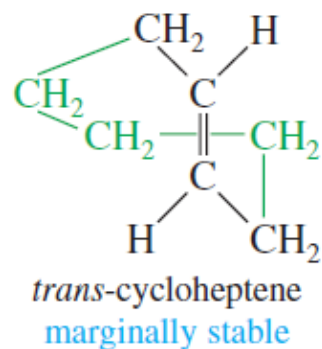
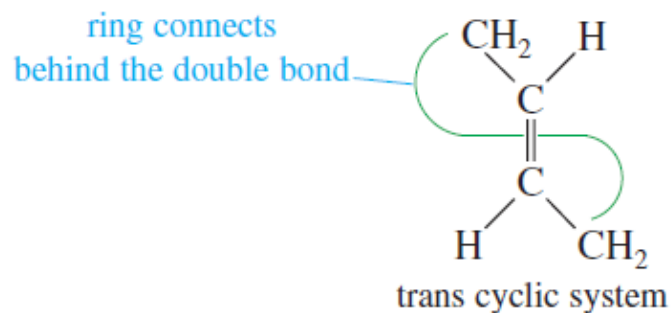


Stability of Cycloalkenes

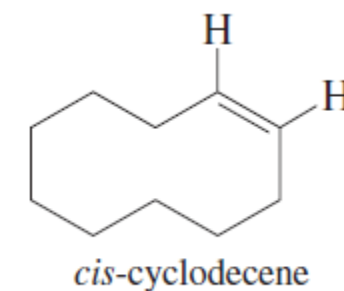
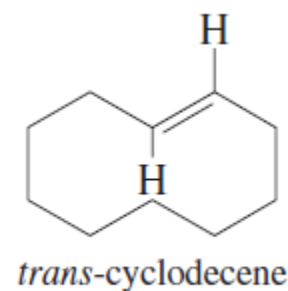
For **acyclic systems**, *trans* alkenes are usually more stable than *cis* isomers.

For ***trans* cycloalkenes**:

- 3 – 6 membered ring = unable to complete the ring systems
- 7 – 9 membered ring = **less stable** than *cis* isomer



- >10 membered ring = nearly as stable as the *cis* isomer



Example 1 Predict which member of each pair is more stable

(a) 2-methylbut-1-ene

(b) *cis,cis*-hexa-2,4-diene

or 3-methylbut-1-ene

or *trans,trans*-hexa-2,4-diene

(c) 1,2-dimethylcyclopropene

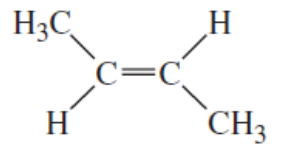
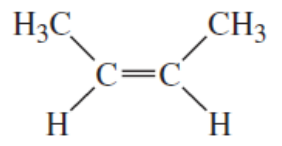
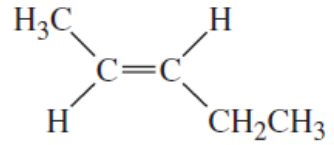
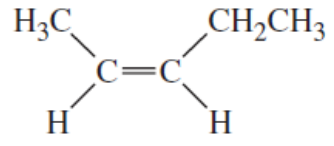
(d) *trans*-1,2-dimethylcyclodecene

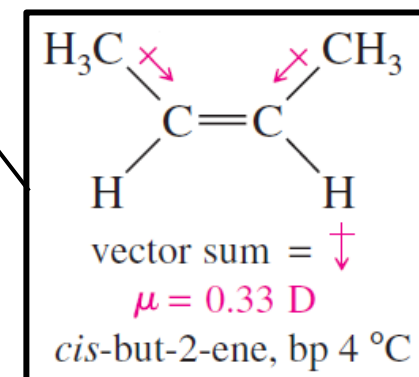
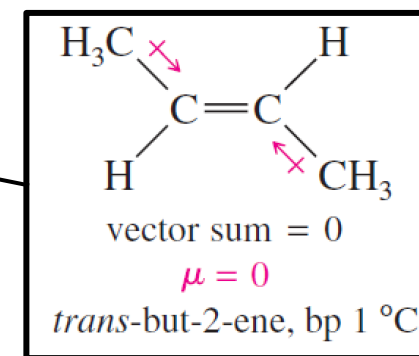
or 1,2-dimethylcyclopentene

or *trans*-1,2-dimethylcycloheptene

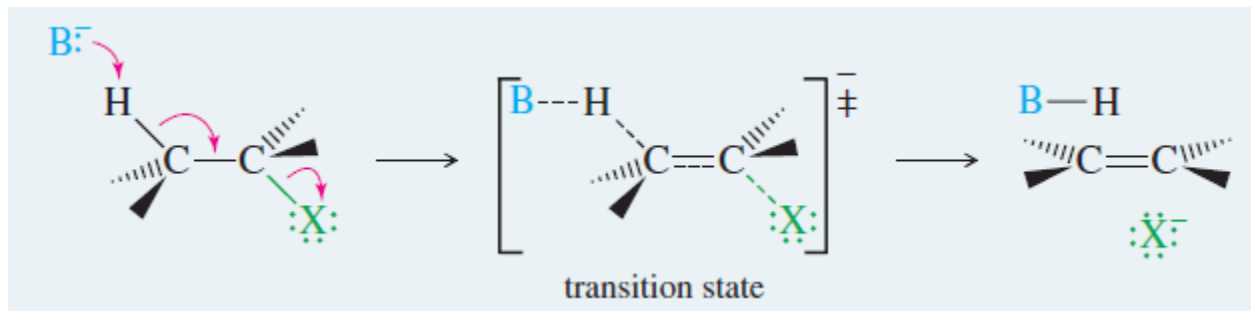
Physical Properties of Alkenes

Boiling Points, Densities, and Polarity: similar to those of the corresponding alkanes

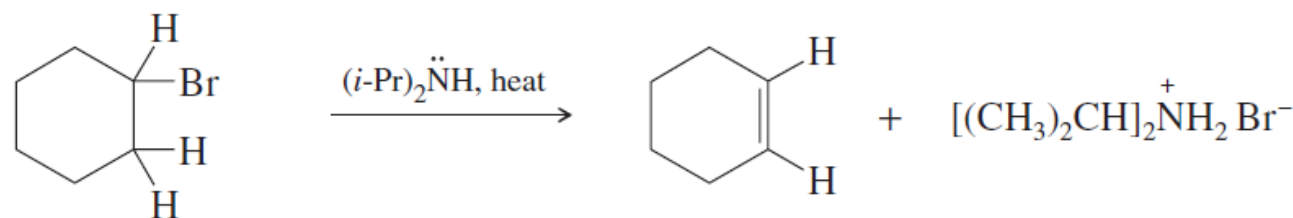
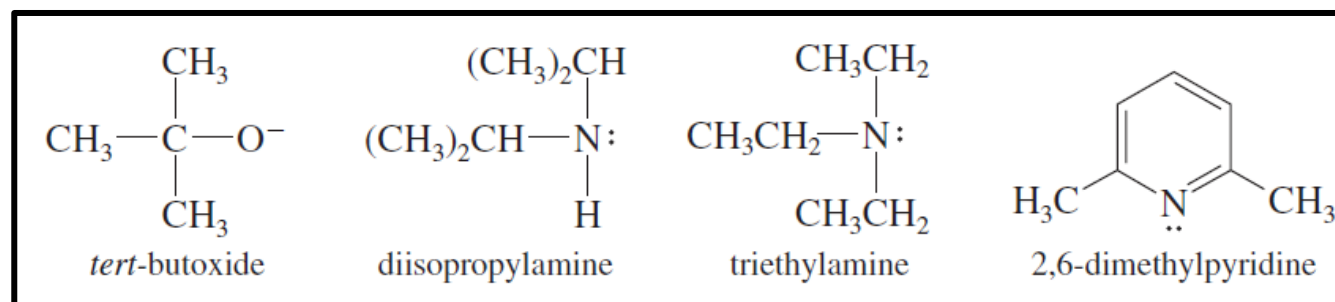
Name	Structure	Carbons	Boiling Point (°C)	Density (g/cm ³)
ethene (ethylene)	CH ₂ =CH ₂	2	-104	
propene (propylene)	CH ₃ CH=CH ₂	3	-47	0.52
2-methylpropene (isobutylene)	(CH ₃) ₂ C=CH ₂	4	-7	0.59
but-1-ene	CH ₃ CH ₂ CH=CH ₂	4	-6	0.59
<i>trans</i> -but-2-ene		4	1	0.60
<i>cis</i> -but-2-ene		4	4	0.62
3-methylbut-1-ene	(CH ₃) ₂ CH-CH=CH ₂	5	25	0.65
pent-1-ene	CH ₃ CH ₂ CH ₂ -CH=CH ₂	5	30	0.64
<i>trans</i> -pent-2-ene		5	36	0.65
<i>cis</i> -pent-2-ene		5	37	0.66
2-methylbut-2-ene	(CH ₃) ₂ C=CH-CH ₃	5	39	0.66
hex-1-ene	CH ₃ (CH ₂) ₃ -CH=CH ₂	6	64	0.68
2,3-dimethylbut-2-ene	(CH ₃) ₂ C=C(CH ₃) ₂	6	73	0.71
hept-1-ene	CH ₃ (CH ₂) ₄ -CH=CH ₂	7	93	0.70
oct-1-ene	CH ₃ (CH ₂) ₅ -CH=CH ₂	8	122	0.72
non-1-ene	CH ₃ (CH ₂) ₆ -CH=CH ₂	9	146	0.73
dec-1-ene	CH ₃ (CH ₂) ₇ -CH=CH ₂	10	171	0.74



- Elimination of Alkyl Halides – E2



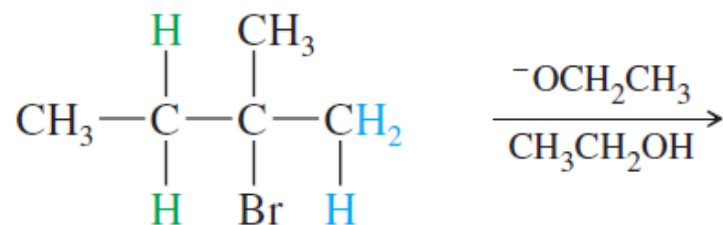
Use of a Bulky Base: If the substrate is prone to substitution, a **bulky base** can minimize the amount of substitution.



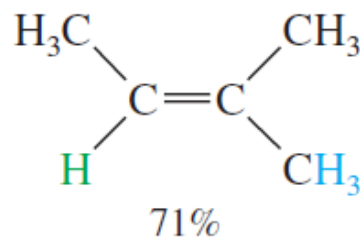
Preparation of Alkenes

- Elimination of Alkyl Halides – E2

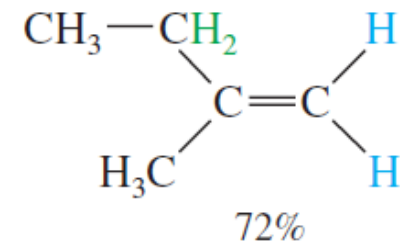
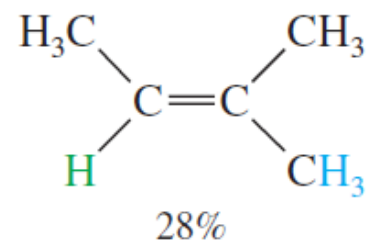
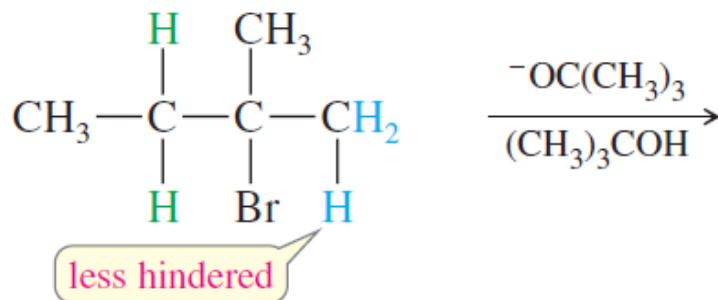
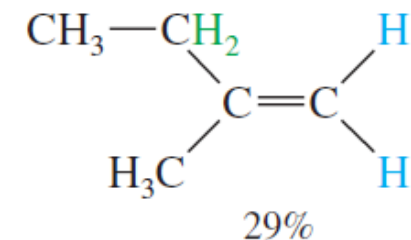
Zaitsev vs. Hofmann product:



Zaitsev product



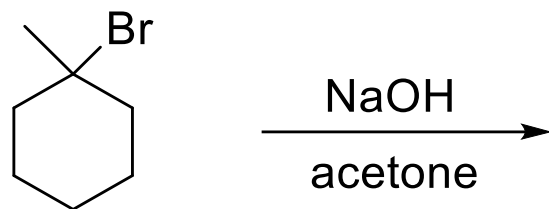
Hofmann product



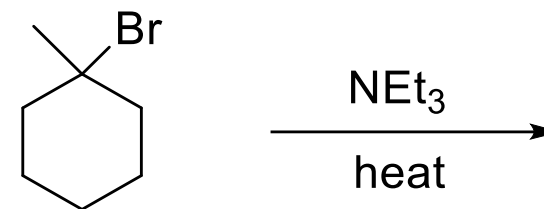
Preparation of Alkenes

Example 2 For each reaction, decide whether substitution or elimination (or both) is possible, and predict the products you expect. Label the major products.

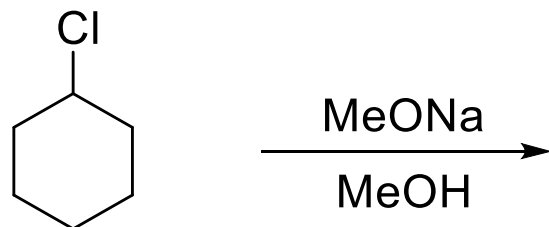
(a)



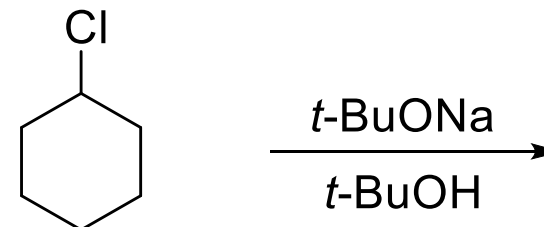
(b)



(c)

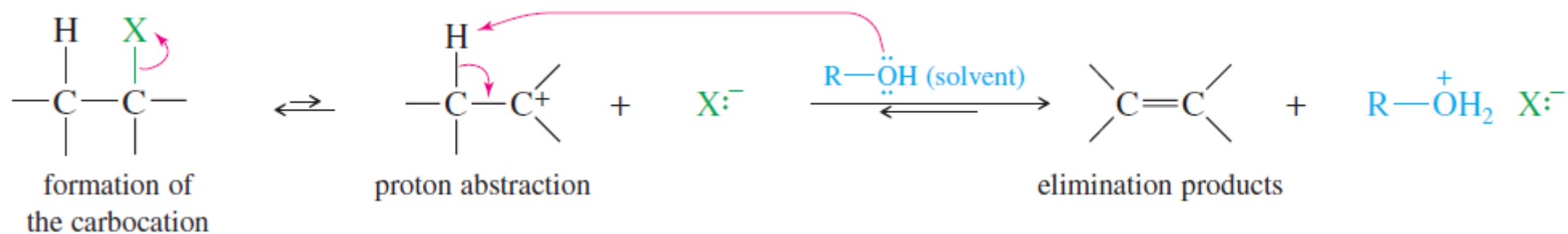


(d)

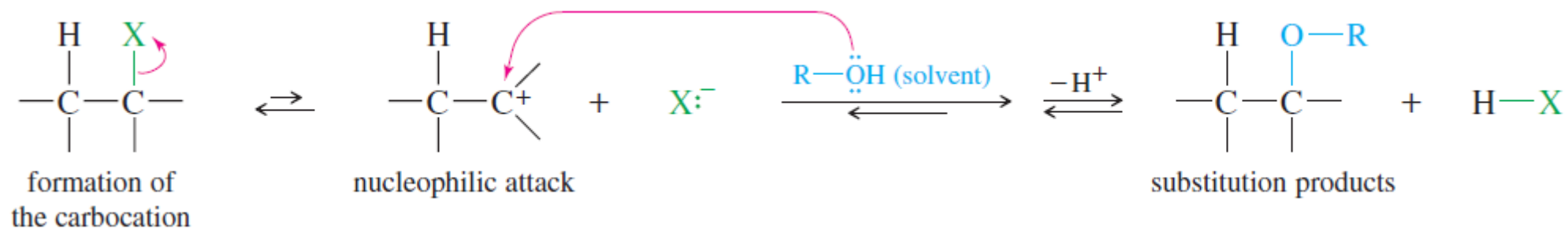


- Elimination of Alkyl Halides – E1

Elimination by the E1 mechanism

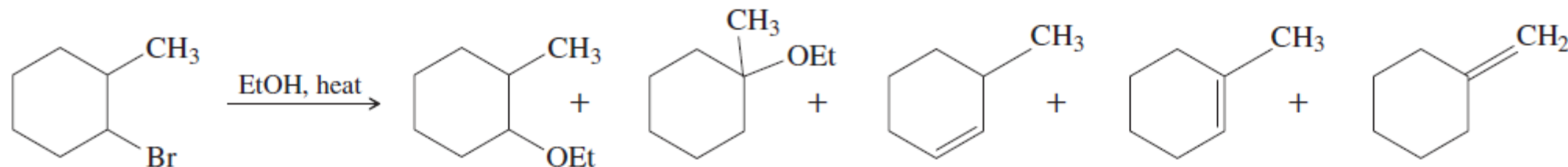


Accompanied by S_N1 substitution

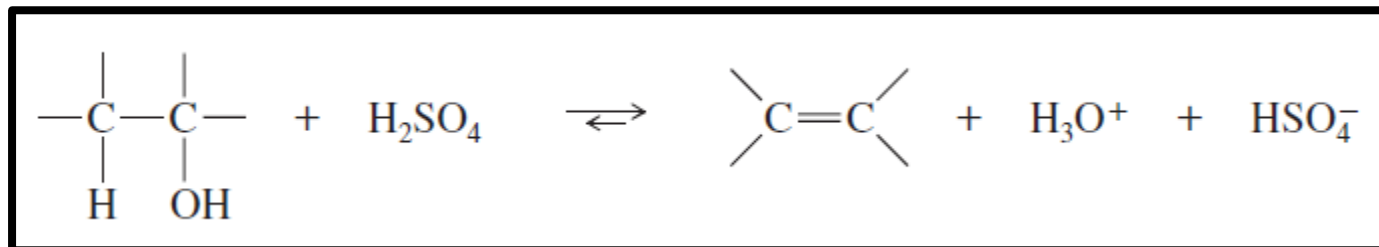


Preparation of Alkenes

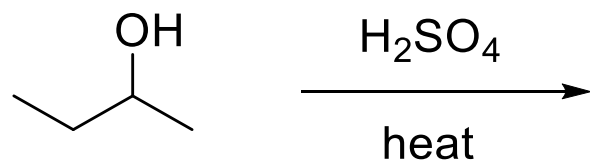
Example 3 Propose mechanisms for the following reactions.



- Dehydration of alcohol



The mechanism of dehydration resembles the **E1 mechanism**. The **hydroxyl group** of the alcohol is a **poor leaving group (OH⁻)** but **protonation** by the acidic catalyst converts it to a **good leaving group (H₂O)**

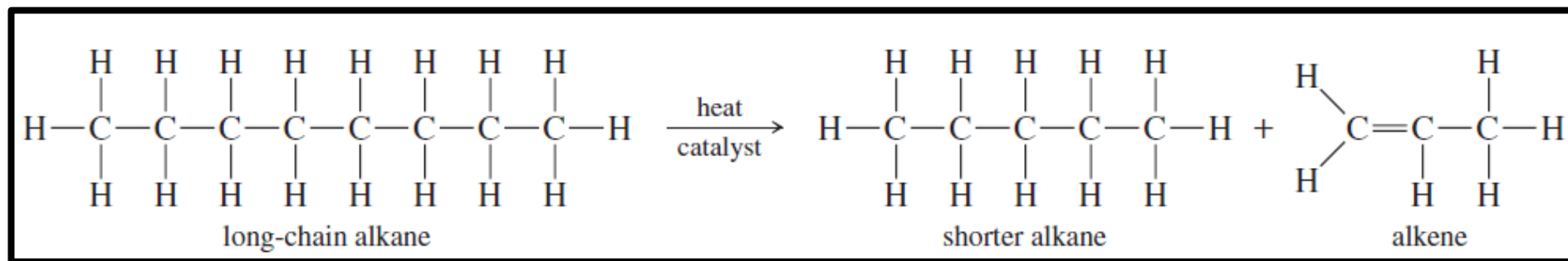


Preparation of Alkenes



High temperature Industrial Methods

- Catalytic Cracking of Alkanes**



- Catalytic Dehydrogenation of Alkanes**

