

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ  
ПОРТФОЛИО  
ПӘНІ: ФИЗИКАЛЫҚ ХИМИЯ

Қ.А.ЯСАУИ АТЫНДАҒЫ ХАЛЫҚАРАЛЫҚ ҚАЗАҚ-ТҮРІК УНИВЕРСИТЕТІ  
ЖАРАТЫЛЫСТАНУ ФАКУЛЬТЕТІ  
ЖХМ-511(Ғ) ТОБЫНЫҢ СТУДЕНТІ МӘЛКЕН.Т.А.

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## ***SIW plan :***

### ❖ **Smart-мақсат**

Lecture :*Heterogeneous catalysis*

- ❖ The basic concept of heterogeneous catalysis
- ❖ Adsorption theory of heterogeneous catalysis
- ❖ Stages of heterogeneous catalysis
- ❖ Concepts

# SMART-МАҚСАТ

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*Интерактивті тақта арқылы студенттерге гетерогенді катализ және оның механизмі мен себептері жайында түсіндіру, нақты жағдаяттарға пікірталас ұйымдастыру арқылы тыңдаушының интеллектуальды ой-өрісі мен дүниетанымын кеңейту.*

# ***PLAN:***

- The basic concept of heterogeneous catalysis
- Adsorption theory of heterogeneous catalysis
- Stages of heterogeneous catalysis
- Concepts

# ***Catalysis***



## **Homogeneous catalysis:**

- When the reactants and catalysts are in the same physical state i.e. catalyst is in the same phase as the reactant is called homogenous catalysis

## **Heterogeneous catalysis**

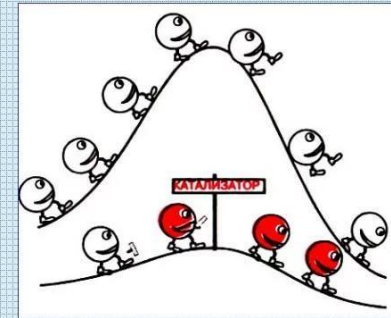
- A catalytic process in which the catalyst and the reactants are in different phases is called heterogeneous catalysis. This process is also called contact or surface catalysis

# HETEROGENEOUS CATALYSIS

In chemistry, heterogeneous catalysis refers to the form of catalysis where the phase of the catalyst differs from that of the reactants. Phase here refers not only to solid, liquid, vs gas, but also immiscible liquids, e.g. oil and water. The great majority of practical heterogeneous catalysts are solids and the great majority of reactants are gases or liquids. Heterogeneous catalysis is of paramount importance in many areas of the chemical and energy industries.

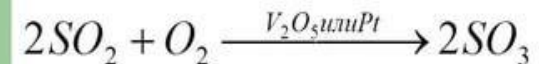
Heterogeneous catalysis has attracted Nobel prizes for Fritz Haber in 1918, Carl Bosch in 1931, Irving Langmuir in 1932, and Gerhard Ertl in 2007.

## Каталіз



## Гетерогенді каталіз

### "КОНТАКТ" ТӘСІЛІ



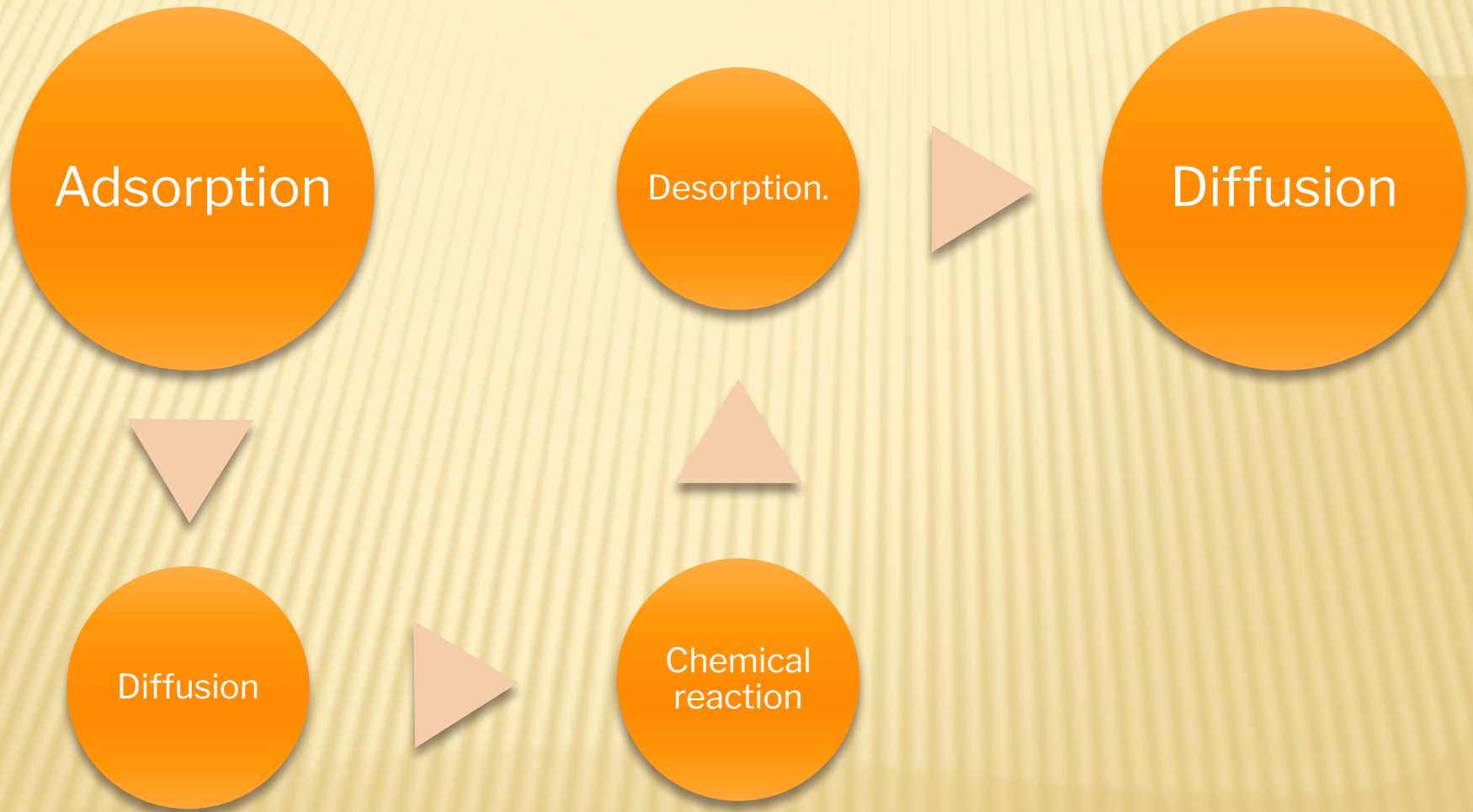
# ***Adsorption theory of heterogeneous catalysis***

- Describes the catalytic processes that occur at the interface of the solid phase (catalyst) and the gas phase (reactants). The central role in the process (HA) is played by physical and chemical adsorption.

## **Adsorption**

Adsorption is the accumulation of molecules at the phase interface. Physical adsorption occurs under the action of van der Waals forces. Chemical adsorption (chemisorption) occurs due to the formation of chemical bonds between adsorbed molecules and the surface.

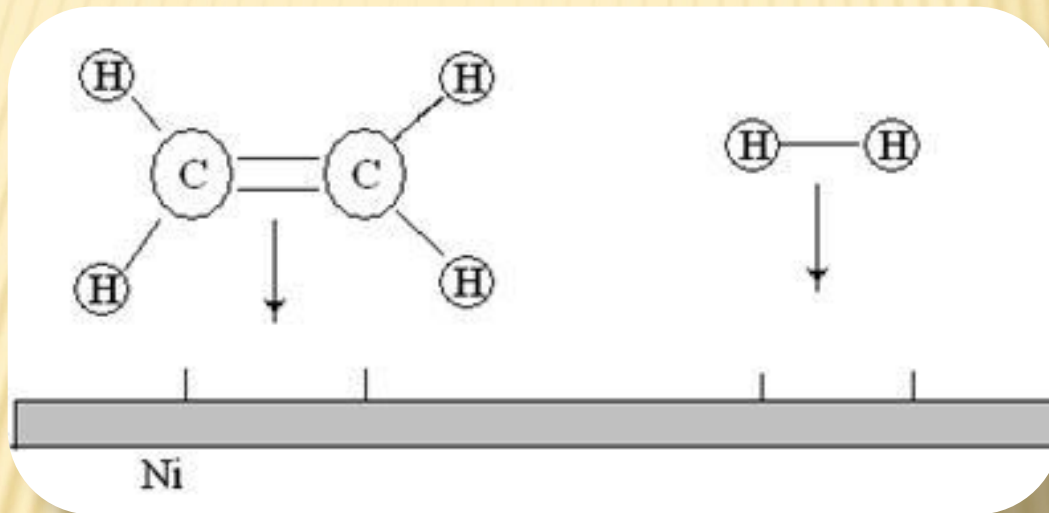
# Stages of heterogeneous catalysis





# Diffusion

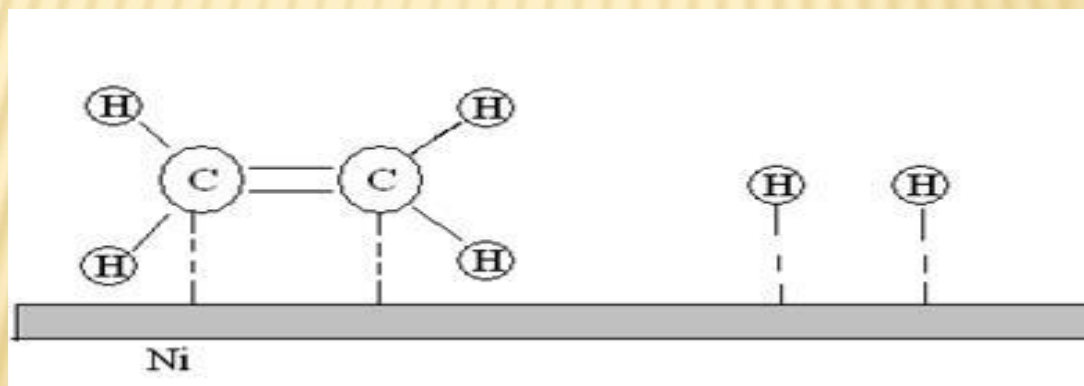
- Reactive molecules diffuse to the surface of a solid.



**Diffusion of ethylene and hydrogen molecules from the gas phase to the surface of a nickel catalyst**

# Adsorption

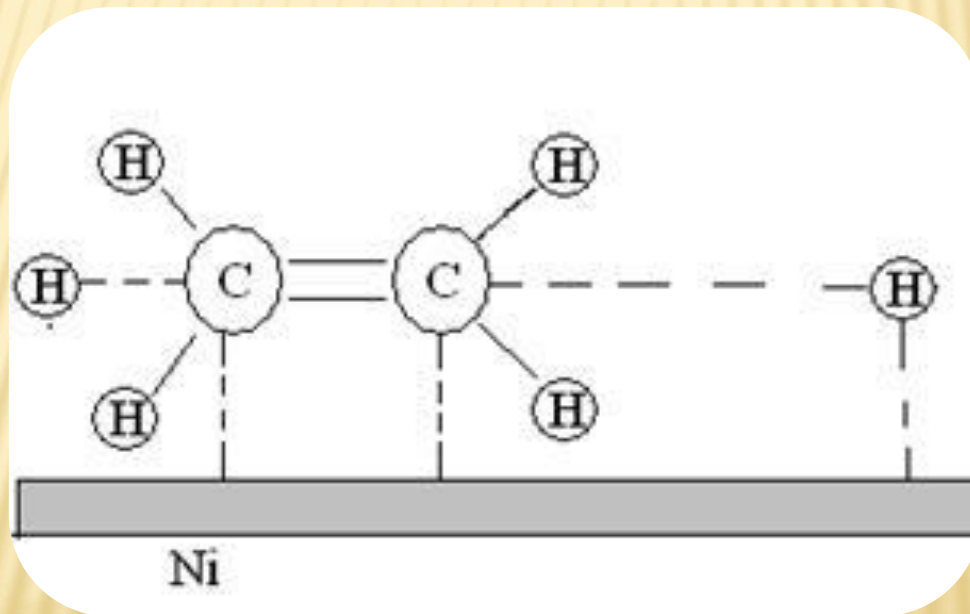
- The reacting molecules are first adsorbed physically, then enter into chemical reactions with active surface centers (chemisorbed). Active centers are free areas of the surface where molecules of reacting substances can be adsorbed. Another part of the surface of the catalyst is occupied by adsorbed impurity molecules. The number of active sites per unit surface depends on the nature and method of preparation of the catalyst.



**Adsorption of ethylene and hydrogen molecules on the surface of a nickel catalyst**

# Chemical reaction

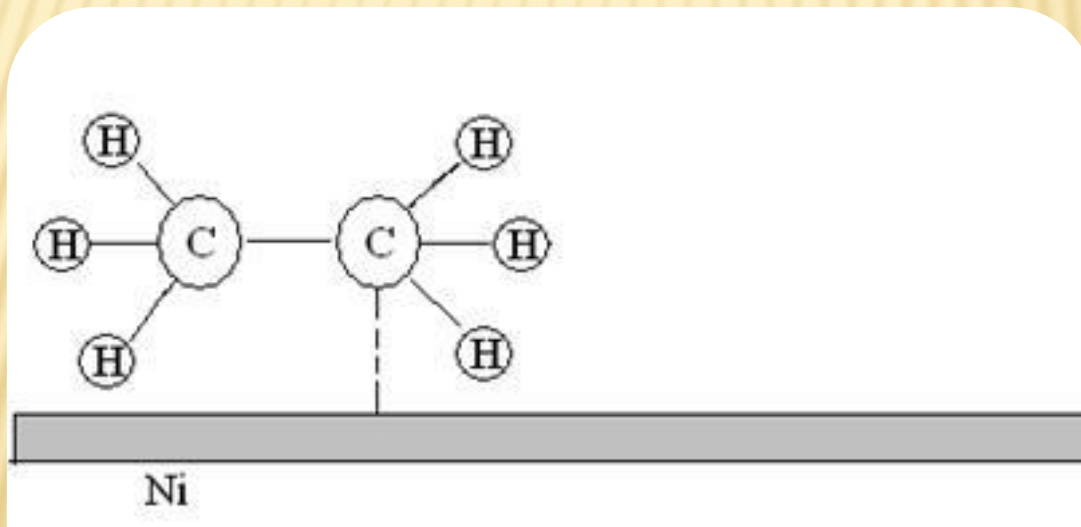
- The adsorbed atoms and molecules react chemically with the formation of products.



**Chemical interaction of ethylene and hydrogen molecules on the surface of a nickel catalyst**

# Desorption.

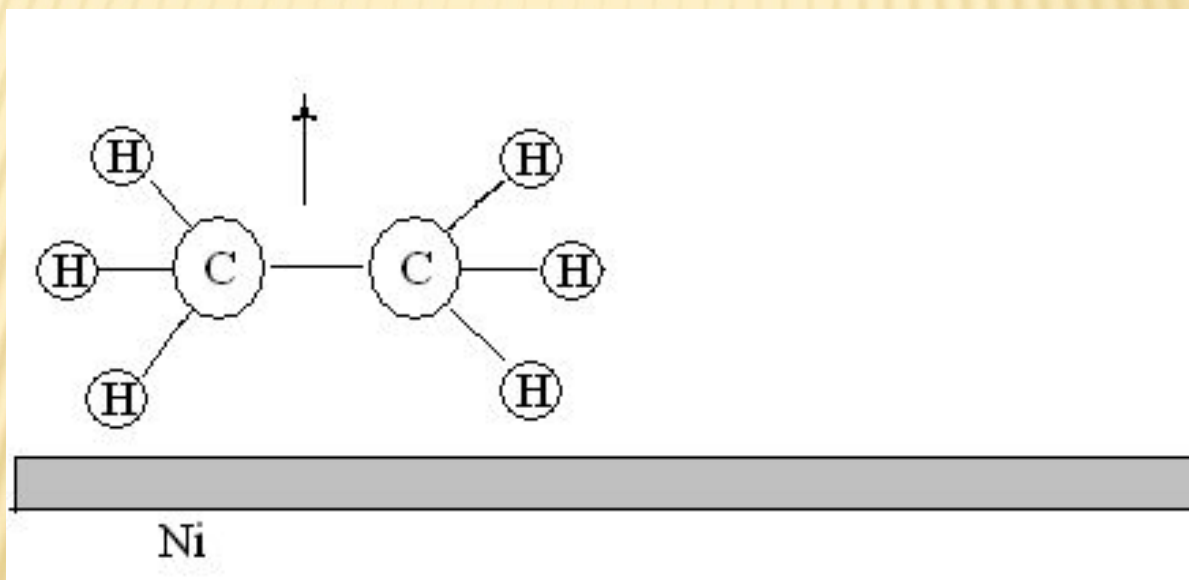
- The molecules of the reaction products pass from the state of chemisorption to the state of physical adsorption and then desorbed from the surface.



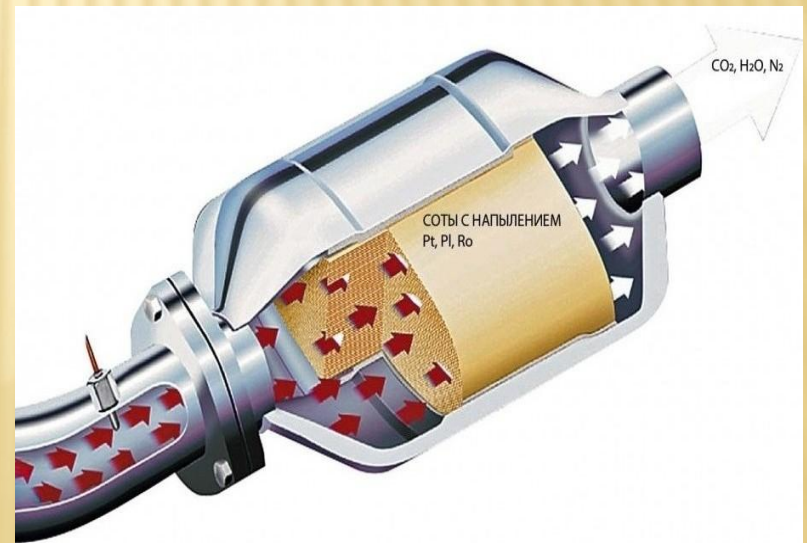
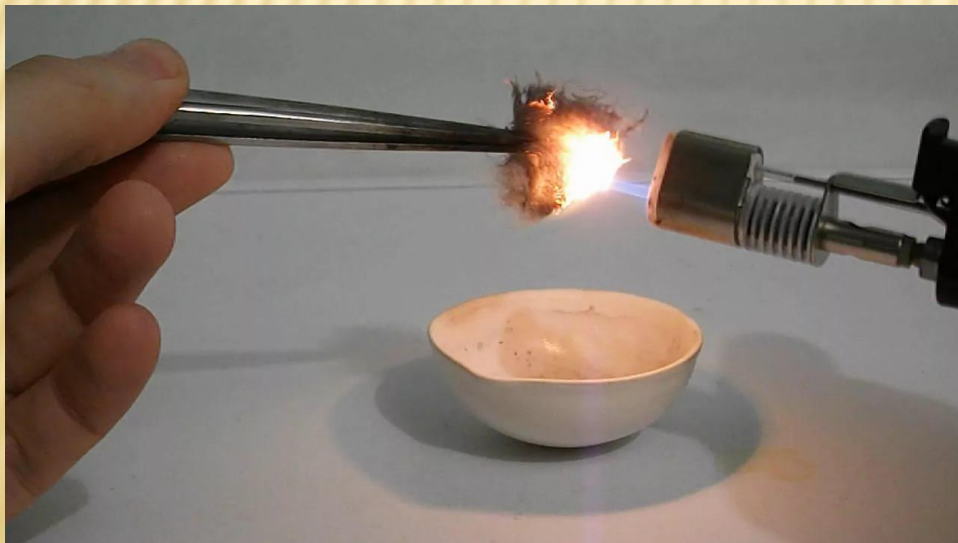
**Desorption of ethane molecules from the surface of a nickel catalyst**

# Diffusion

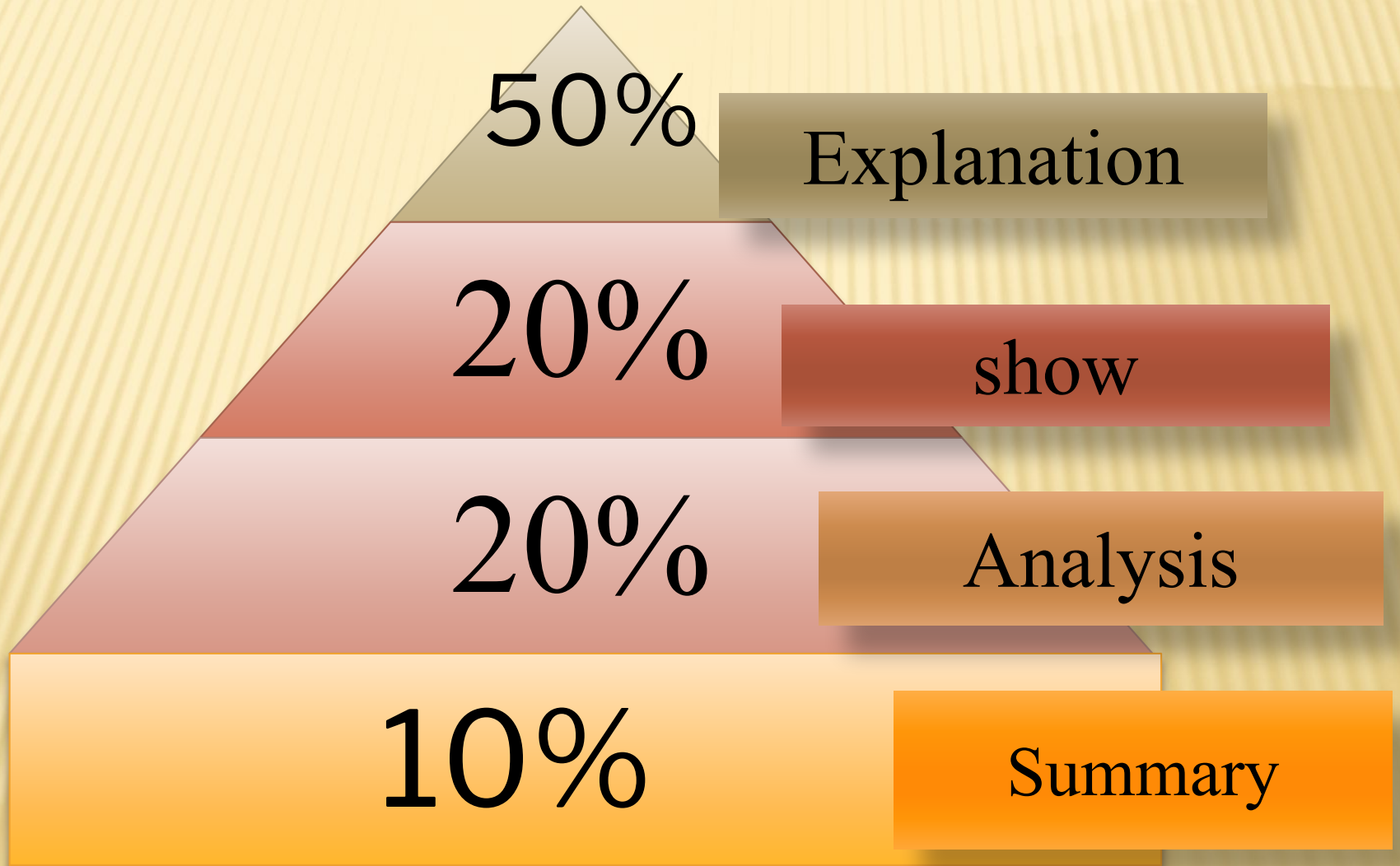
- The molecules of the reaction products diffuse from the surface.



**Diffusion of ethane molecules from the surface of the nickel catalyst to the gas phase**



# Chart



# **CONCEPTS**

In heterogeneous catalysis, the reactants diffuse to the catalyst surface and adsorb onto it, via the formation of chemical bonds. After reaction, the products desorb from the surface and diffuse away. Understanding the transport phenomena and surface chemistry such as dispersion is important. If diffusion rates are not taken into account, the reaction rates for various reactions on surfaces depend solely on the rate constants and reactant concentrations. For solid heterogeneous catalysts, the surface area of the catalyst is critical since it determines the availability of catalytic sites. Surface areas can be large, for example some mesoporous silicates have areas of 1000 m<sup>2</sup>/g. The most common approach to maximizing surface area is by the use of catalyst supports, which are the materials over which the catalysts are spread.



# REFERENCES

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- Molecular mechanism of heterogeneous catalysis. Resonance Vol. 13 Issue 6 (2008) p. 548-560.
- Frank, B.; Blume, R.; Rinaldi, A.; Trunschke, A.; Schlögl, R. (2011). "Oxygen Insertion Catalysis by  $sp^2$  Carbon". *Angew. Chem. Int. Ed.* **50** (43): 10226–10230. [doi:10.1002/anie.201103340](#).
- Sheehan, D.P., Nonequilibrium heterogeneous catalysis in the long mean-free-path regime, *Phys. Rev. E* 88 032125 (2013).