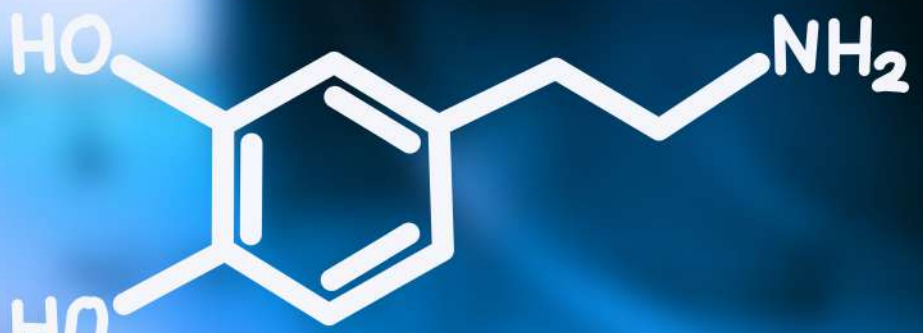
# Organic 1

لجان الدُّفعات

DOPAMINE ACADEMY

## Subject: Lecture 4




Dopamine

25-7-2024

# Intermolecular Forces and Liquids and Solids

# Intermolecular Forces

***Intermolecular forces*** are attractive forces **between** molecules.

***Intramolecular forces*** hold atoms together in a molecule.

## Intermolecular vs Intramolecular

- 41 kJ to vaporize 1 mole of water (**inter**)
- 930 kJ to break all O-H bonds in 1 mole of water (**intra**)

## "Measure" of intermolecular force

Generally, **inter**molecular forces are much weaker than **intra**molecular forces.

boiling point

melting point

# Intermolecular Forces

## Dipole-Dipole Forces

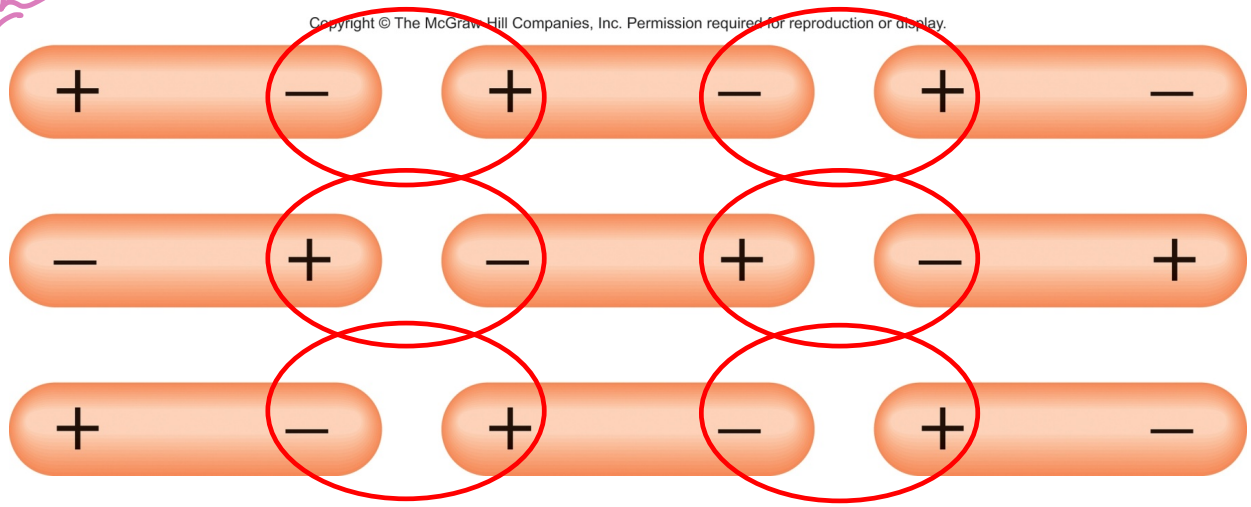
تجاذب

Attractive forces between **polar molecules**

العلاقة بينهم
حيث المسافة
عكسية

Orientation of Polar Molecules in a Solid






Attraction between opposite charges depends on distance

لو تزيد المسافة بينهم بضعف
الطاقة الحركية وتقل الـ Force
مع يعمل كسر الـ bonds

# Intermolecular Forces

Dipole

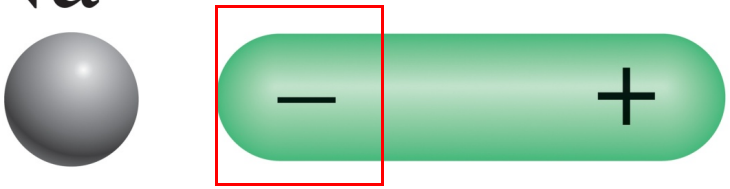
Attractive forces between an **ion** and a **polar molecule**

**Ion-Dipole Interaction**

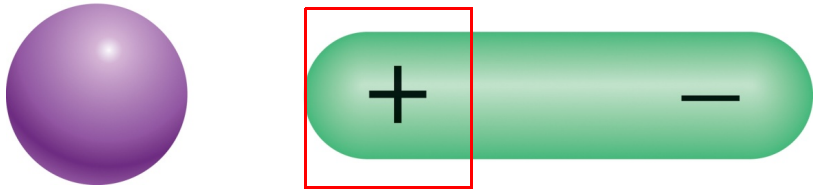
متعادل ← ضاربه انطاب



cation $Na^{+}$




anion $I^{-}$



# London forces (dipole-induced dipole attraction)

Non-polar molecules do not have dipoles like polar molecules. How, then, can non-polar compounds form solids or liquids?

London forces (also called van der Waal forces) are due to small dipoles that exist in non-polar molecules

Because electrons are moving around in atoms there will be instants when the charge around an atom is not symmetrical

The resulting tiny dipoles cause attractions between atoms/molecules **(the greater the mass, the greater the London forces)**

3 names :

1. London forces
2. dipole-induced dipole attraction
3. van der Waal forces

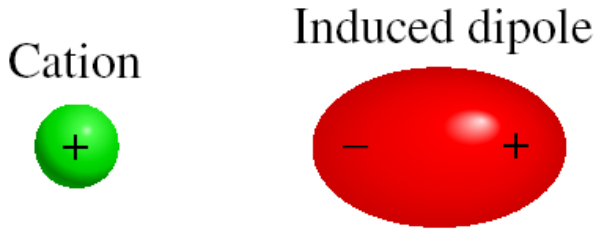
dipoles: ثنائيات القطب

London: weak bond

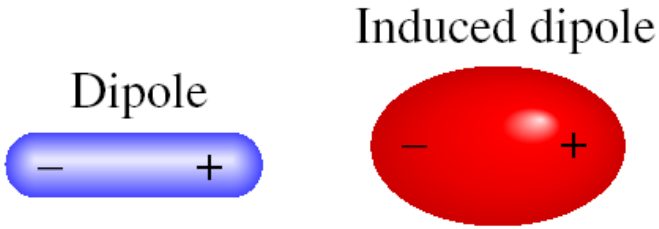
# Intermolecular Forces

## Dispersion Forces

Attractive forces that arise as a result of **temporary dipoles induced** in atoms or molecules



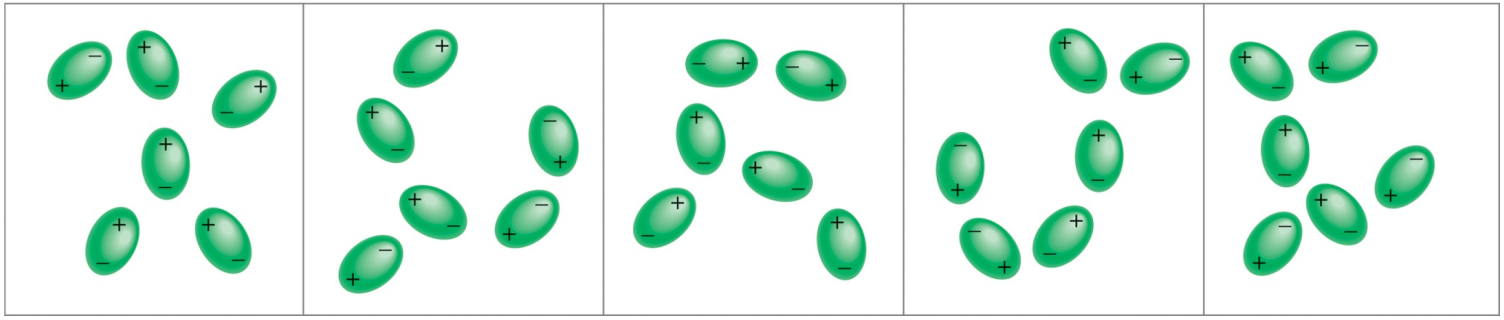

ion-induced dipole interaction




dipole-induced dipole interaction

# Induced Dipoles Interacting With Each Other





# Intermolecular Forces

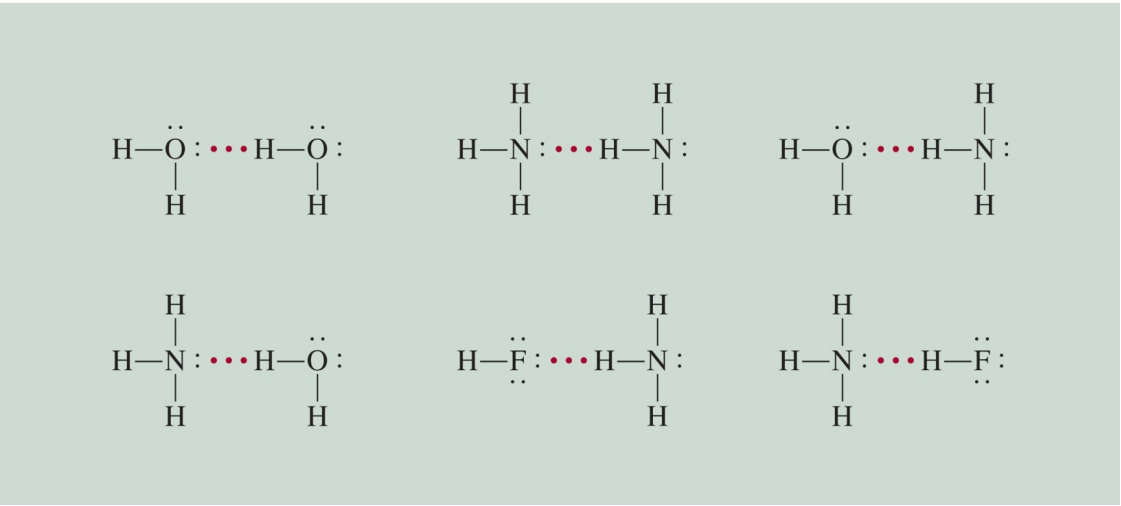
## Hydrogen Bond

The ***hydrogen bond*** is a special dipole-dipole interaction between the hydrogen atom in a polar N-H, O-H, or F-H bond and an electronegative O, N, or F atom.

$A — H \cdots B$ or $A — H \cdots A$

A & B are N, O, or F





# Saturated Hydrocarbons
# 1. Alkanes

## Physical Properties

## C. Boiling Points

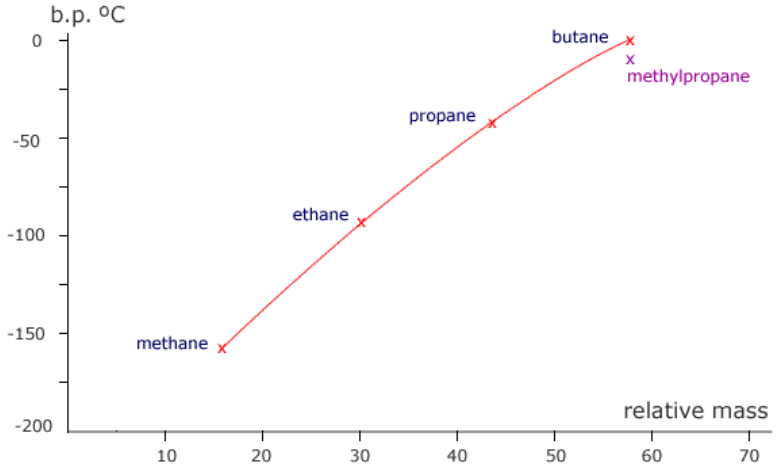
2 factors effect the ↑

branching ↑ ← كل ما زاد الـ branching كانت الـ boiling point أقل

ex:

| $CH_3CH_2CH_2CH_3$ | $H_3C-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_3$ |
|---|---|
| *n*-Butane | Isobutane |
| b.p.=0°C | b.p.=-12°C |

| $CH_3CH_2CH_2CH_2CH_3$ | $H_3CH_2C-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_3$ | $H_3C-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{\vert}{\underset{\vert}{C}}}}-CH_3$ |
|---|---|---|
| *n*-Pentane | Isopentane | Neopentane |
| b.p.=36°C | b.p.=28°C | b.p.=9.5°C |



Graph showing boiling point of the alkanes against relative mass

- Boiling point decreases with increasing branches
- Boiling point increases with increasing molecular weight

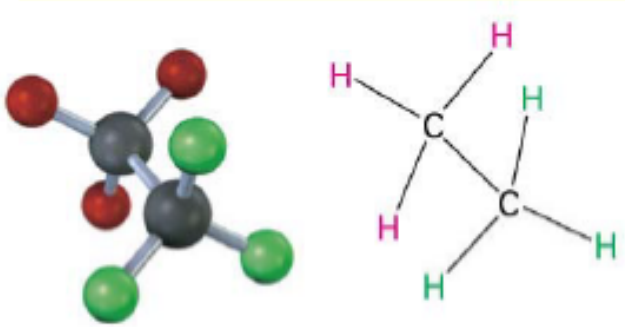
number of carbons ↑ → Boiling point ↑ لـ علاقة طردية

→ highst boiling point:
→ high num of carbon
→ loust branching.

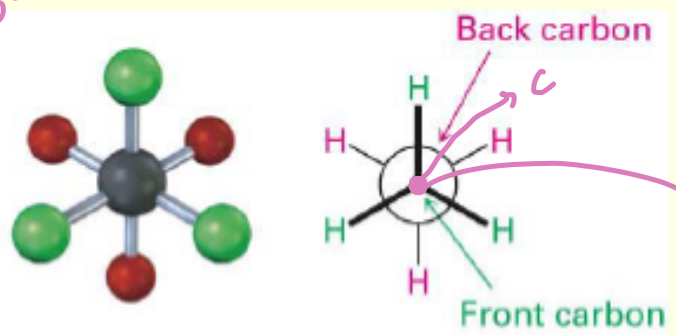
عند الـ gas state لـ bp أقل ← أقل من 4c

# Conformational Isomers of Alkanes

Isomers that differ as a result of sigma bond Isomers that differ as a result of sigma bond rotation of C-C bond in alkanes




Sawhorse representation



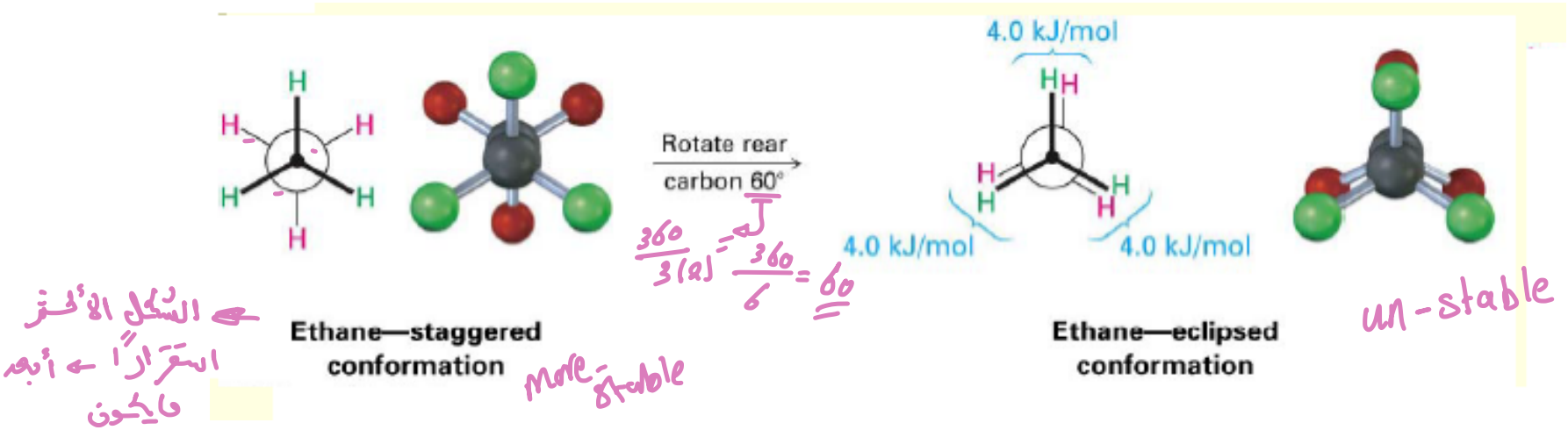

Newman projection

→ single bonds in alkane

→ same properties for isomers.

# Bond Rotation and Newman Projections

As carbon As carbon -carbon bond rotates, interconvert carbon bond rotates, interconvert between staggered and eclipsed conformers



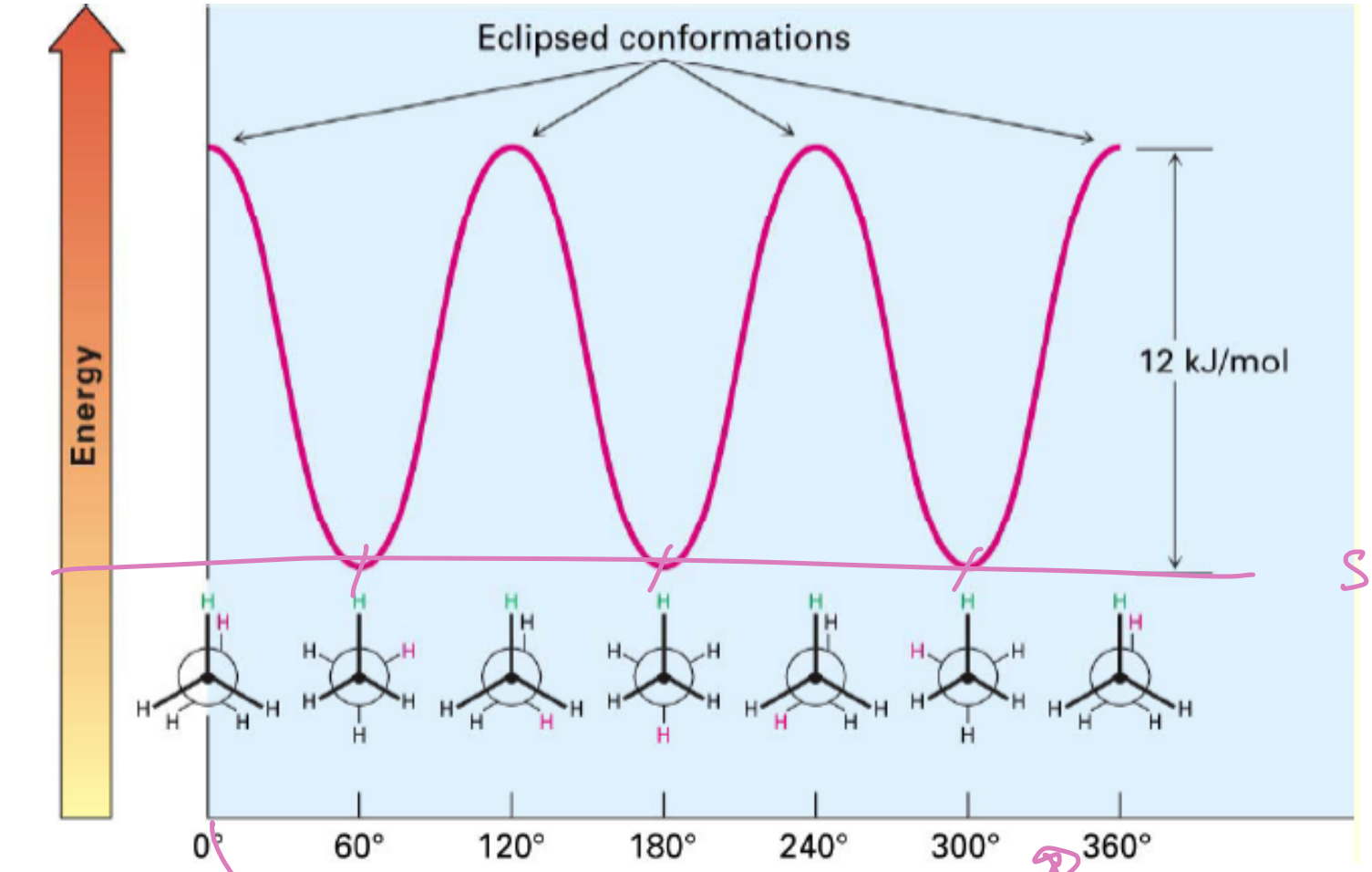

Eclipsed conformer is 12.0 kJ/mol higher in energy ('free' rotation at room temperature)

# Torsional Strain Energy

تحاكس طاقة الدوران ( rotation )

Force that opposes rotation due to the repulsion Force that opposes rotation due to the repulsion of bonding electrons

➢We do not observe perfectly free rotation
➢There is a barrier to rotation, and some conformers are more stable than others
➢Small energy barrier easily overcome at RT
➢Each eclipsed H-H costs 4 kJ/mol of Torsional Energy




staggered

energy ↓
↳ more stable

# Strain Energy in Alkanes

Torsional Strain

Steric strain- repulsive interaction occurring between atoms that are forced closer together than their at far from each other.

**Table 3.5 | Energy Costs for Interactions in Alkane Conformers**

| Interaction | Cause | Energy cost (kJ/mol) | Energy cost (kcal/mol) |
|---|---|---|---|
| H⟷H eclipsed | Torsional strain | 4.0 | 1.0 |
| H⟷$CH_3$ eclipsed | Mostly torsional strain | 6.0 | 1.4 |
| $CH_3$⟷$CH_3$ eclipsed | Torsional and steric strain | 11 | 2.6 |
| $CH_3$⟷$CH_3$ gauche | Steric strain | 3.8 | 0.9 |

# Saturated Hydrocarbons
# 1. Alkanes

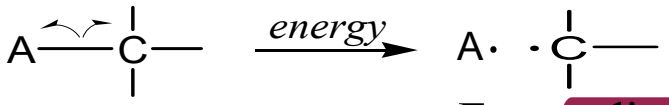
## Notations for bond breaking and bond making

- A covalent bond can be broken in either two ways,

every atom with their electron

➢ **Homolytic cleavage**

كل ذرة بتوخذ الكترونها

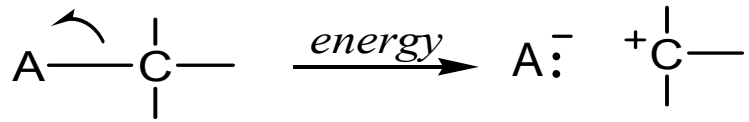



متعارضين

high reacted

➢ **Heterolytic cleavage**

لي أغلب التفاعلات عنا بتكون heterolytic

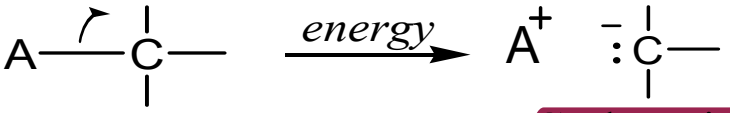



يعتمد على carbon charge

$C^+$

high energy لحتى تصير بدي

لهيك أغلب التفاعلات عنا not - homolytic




$C^-$

break ↙ covelant Bonds

# Saturated Hydrocarbons
## 1. Alkanes

## Preparation of Alkanes

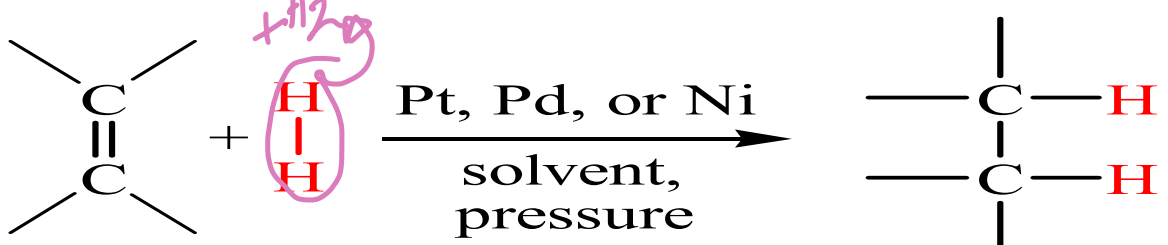
### 1) Hydrogenation of Alkenes and Alkynes

**A great number of alkanes can be obtained by fractional distillation of crude petroleum and subsequent reactions as follows:**

1. **Catalytic hydrogenation:**

***Alkenes and alkynes react with hydrogen in the presence of metal catalysts such as nickel, palladium, and platinum to produce alkanes.***

*General Reaction*



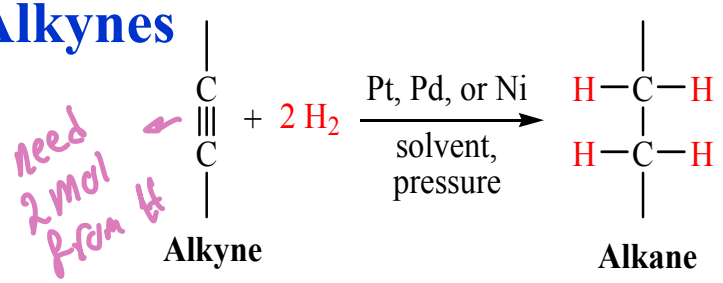

**Alkene** **Alkane**

metal catalysts:
1- nickel
2- platinum
3- palladium
→ to produce alkanes

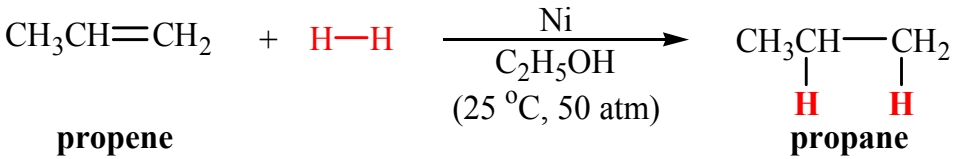
# Saturated Hydrocarbons
# 1. Alkanes

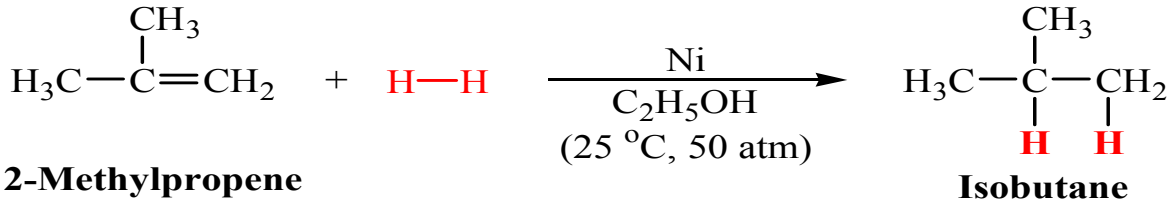
## Preparation of Alkanes

### 1) Hydrogenation of Alkenes and Alkynes




- ***Specific Examples***



R: any alkyl group

# Saturated Hydrocarbons
# 1. Alkanes

## Preparation of Alkanes

### 2) Hydrolysis of Grignard Reagent

تحليل

$$R{-}MgX + HOH \longrightarrow RH + MgX(OH)$$

* Alkyl magnesium halide (Grignard reagent)

- ***Grignard reagents*** **react readily with any source of protons to give hydrocarbons.**

معادلة تحضير وتحليل Grignard

$$CH_3CH_2Br + Mg \xrightarrow{\text{Dry Ether}} CH_3CH_2MgBr$$

Ethyl bromide — Ethyl magnesium bromide (Grignard reagent)

$$CH_3CH_2MgBr + HOH \xrightarrow{H_2O} CH_3CH_3 + MgBr(OH)$$

Ethane

### 3) By coupling of alkyl halides with dialkyl cuprate (all kinds of alkanes)

$$(CH_3CH_2)_2CuLi \xrightarrow{CH_3Br} CH_3CH_2CH_3$$

$CH_3CH_2CuLi$ $CH_3CH_2$

carbon يزاد عددي

# Saturated Hydrocarbons
# 1. Alkanes

## Reactions of Alkanes

**Saturated** hydrocarbons undergo very few reactions, so they are called **Paraffinic hydrocarbons**. (Latin *parum*, little; *affinis*, affinity)

### Halogenation

**The halogenation of an alkane appears to be a simple free radical substitution in which a C-H bond is broken and a new C-X bond is formed**

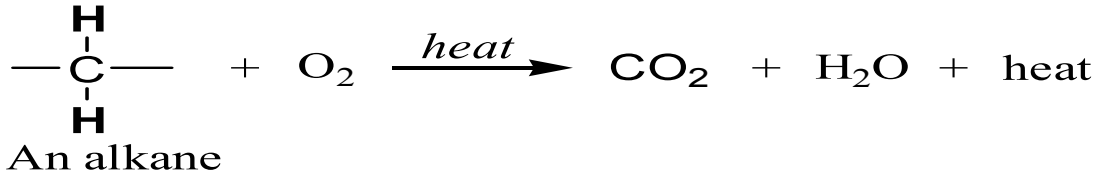
$$RH + X_2 \xrightarrow[\text{or UV light}]{\text{Heat}} RX + HX \qquad X = Cl \text{ or } Br$$

Alkyl halide

Reactivity $X_2$: $Cl_2 > Br_2$

H: $3^0 > 2^0 > 1^0 > CH_3\text{-}H$

### Combustion




An alkane