Sec. Sch. - HKUST Dual Program Level 1

Introductory Chemistry SAMPLE 02

Dept of Chemistry, HKUST

The Quantum Model: Quantum Numbers

Each subshell contains one or more orbitals.

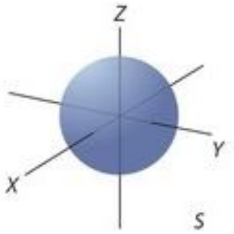
s subshells have 1 orbital.

p subshells have 3 orbitals.

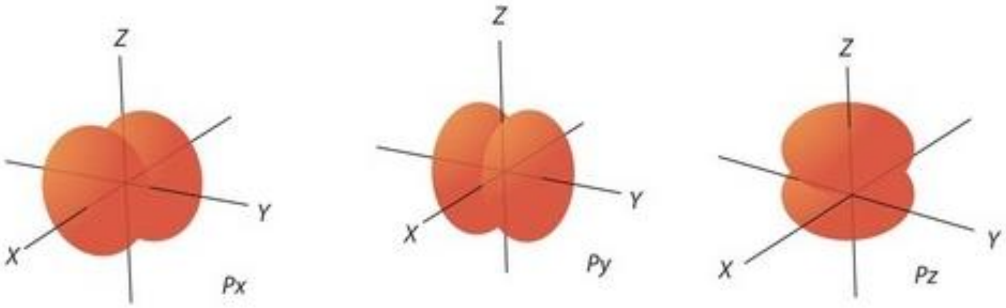
d subshells have 5 orbitals.

f subshells have 7 orbitals.

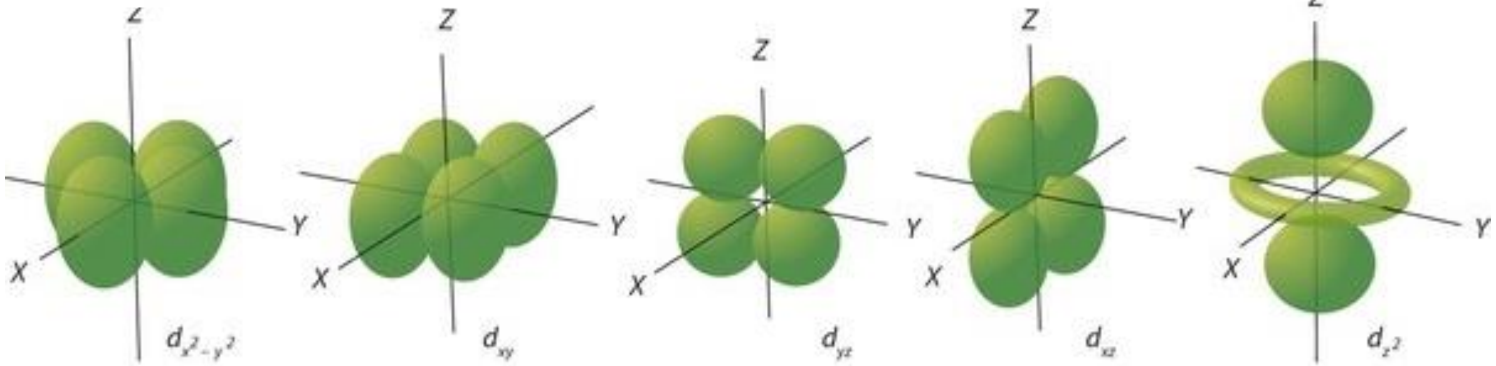
s *orbital*



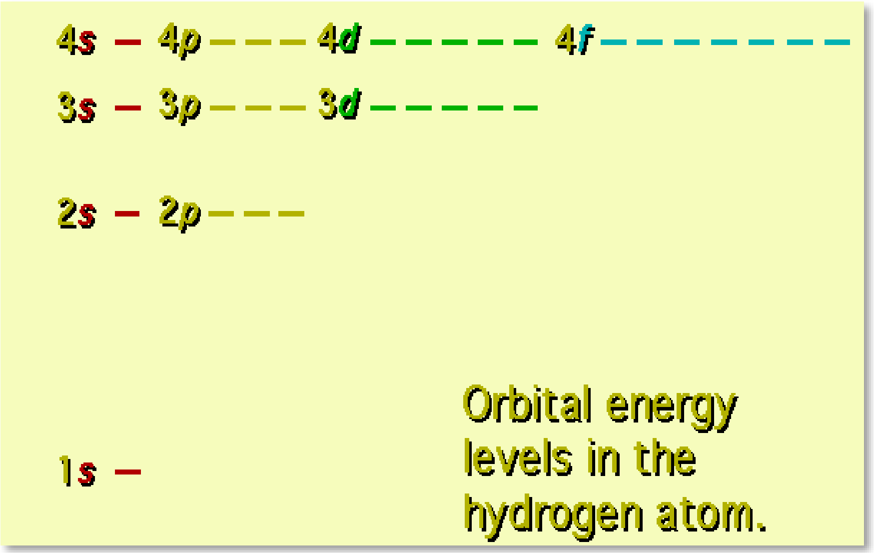
p *orbital*

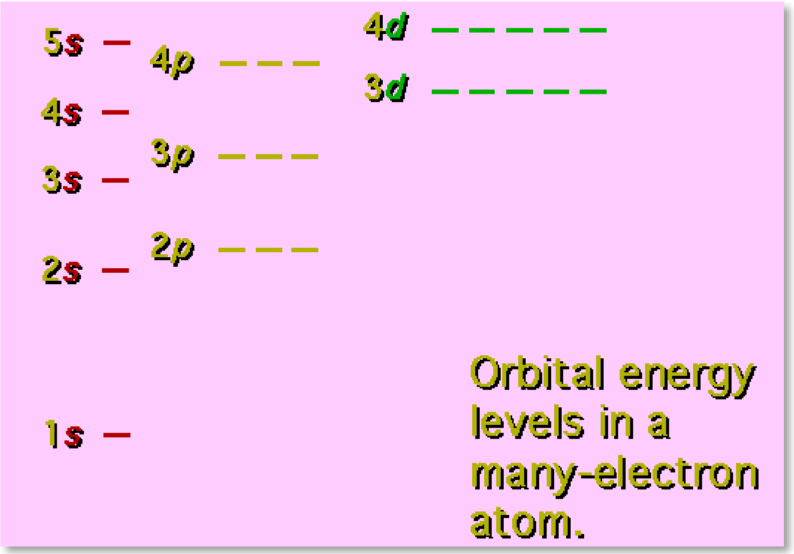


d *orbital*



Energy levels of atomic orbitals of atoms





Orbitals with same n have the same energy.

Orbitals in different subshell of same n have different energy.

- The subshells in a shell of H all have the same energy, but
- but for many electron atoms the subshells have different energies. i.e. $s < p < d < f$.

Molecular shape

No of bonded atoms	No of NBP	No of sets	Molecular shape	e.g.
2	0	2	?	$BeCl_2$, $HgCl_2$, CO_2, HCN
3	0	3	?	BF_3, $AlBr_3$, CH_2O
4	0	4	?	CH_4, CBr_4, $SiCl_4$
3	1	4	?	NH_3, PH_3
2	2	4	?	H_2O, H_2S, SCl_2
2	1	3	?	SO_2, O_3

The Gas Laws

Avogadro's law:

At fixed temperature and pressure, the volume of a gas is directly proportional to the amount of gas (*that is, to the number of moles of gas*, **n**, *or to the number of molecules of gas*)

$$V \propto n$$

Thus,

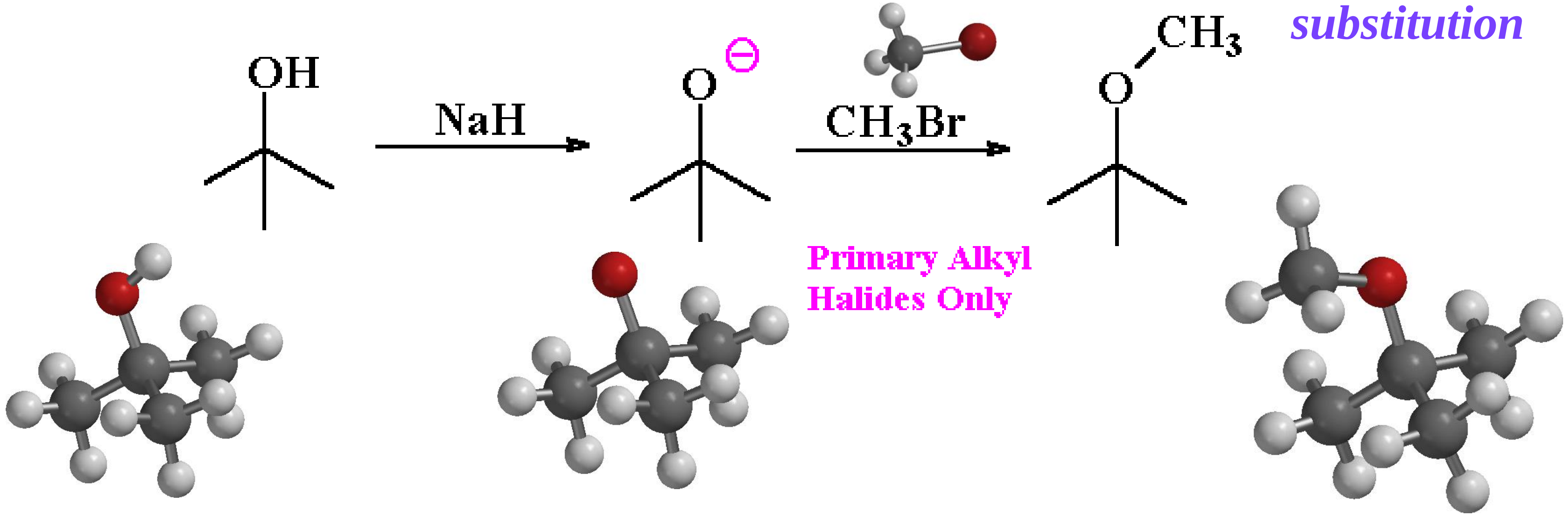
$$V = c \times n$$

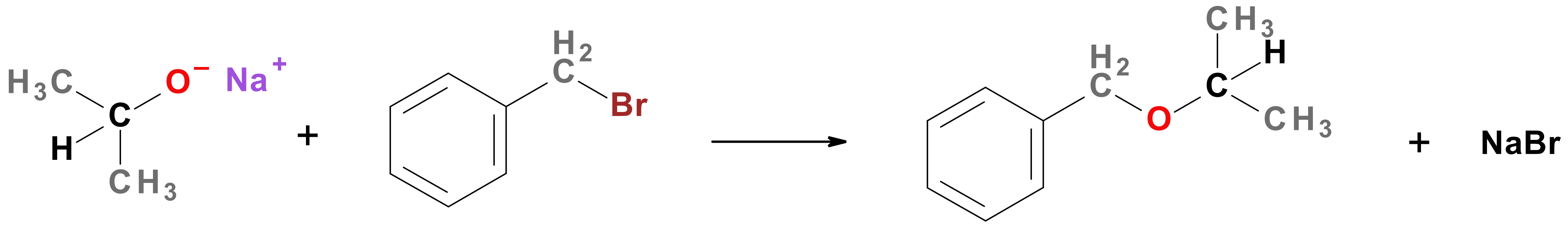
$$V/n = c$$

$$V_1/n_1 = V_2/n_2$$

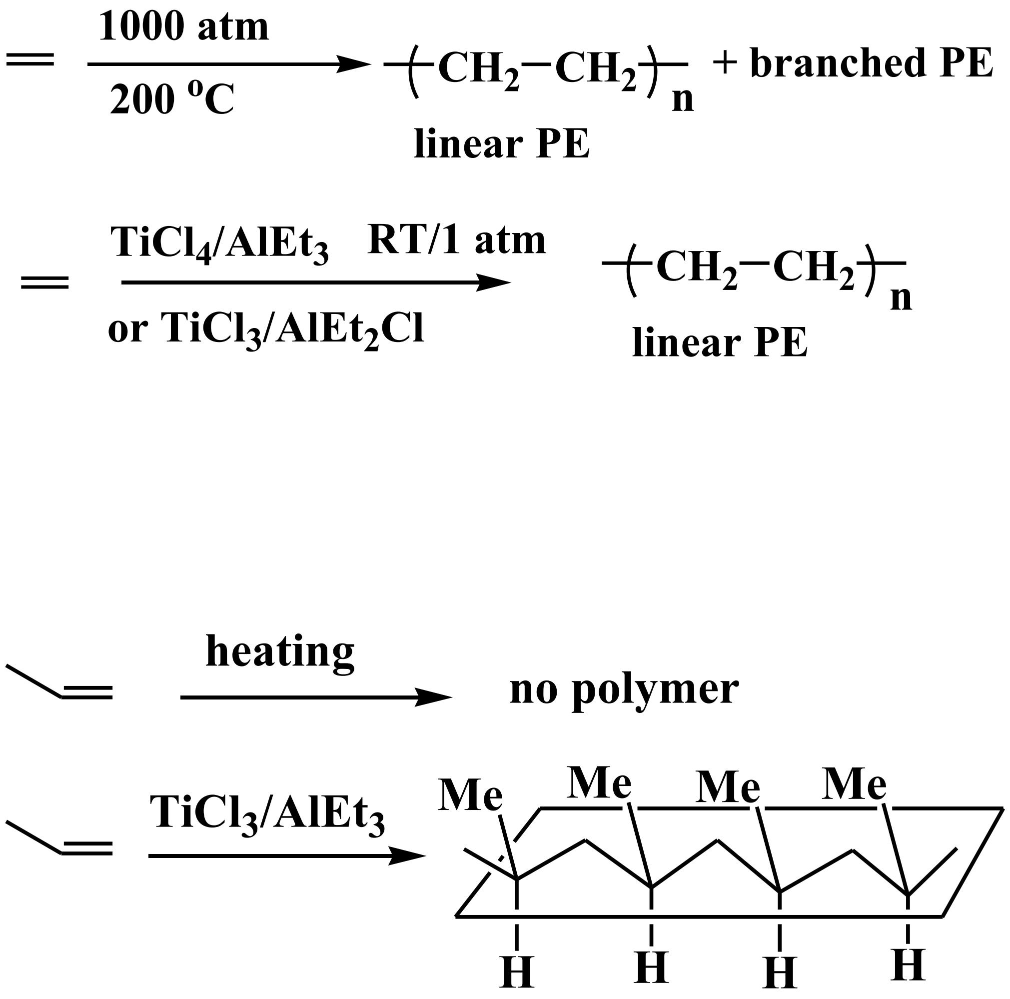
How to make ethers?

Nucleophilic substitution





Co-ordination polymerization



- An efficient catalytic polymerization procedure was developed by Karl Ziegler and Giulio Natta in the 1950's.
- For this important discovery these chemists received the 1963 Nobel Prize in chemistry.
- Currently more than 15 million tones of polyethylene and polypropylene are produced annually through this process.

Hess's law of constant heat summation

- **Worked example:** Determination of this enthalpy change of this reaction: **$2C(graphite) + O_2(g) \rightarrow 2CO(g)$ ΔH_3**

- The direct determination of ΔH_3 is very difficult, because once CO(g) forms it reacts further with O_2 to yield CO_2.

- ΔH of combustion of CO(g) and C(graphite, s) can be easily measured experimentally:

<u>(1)</u>: $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$ $\Delta H_1 = -566 \text{ kJ mol}^{-1}$

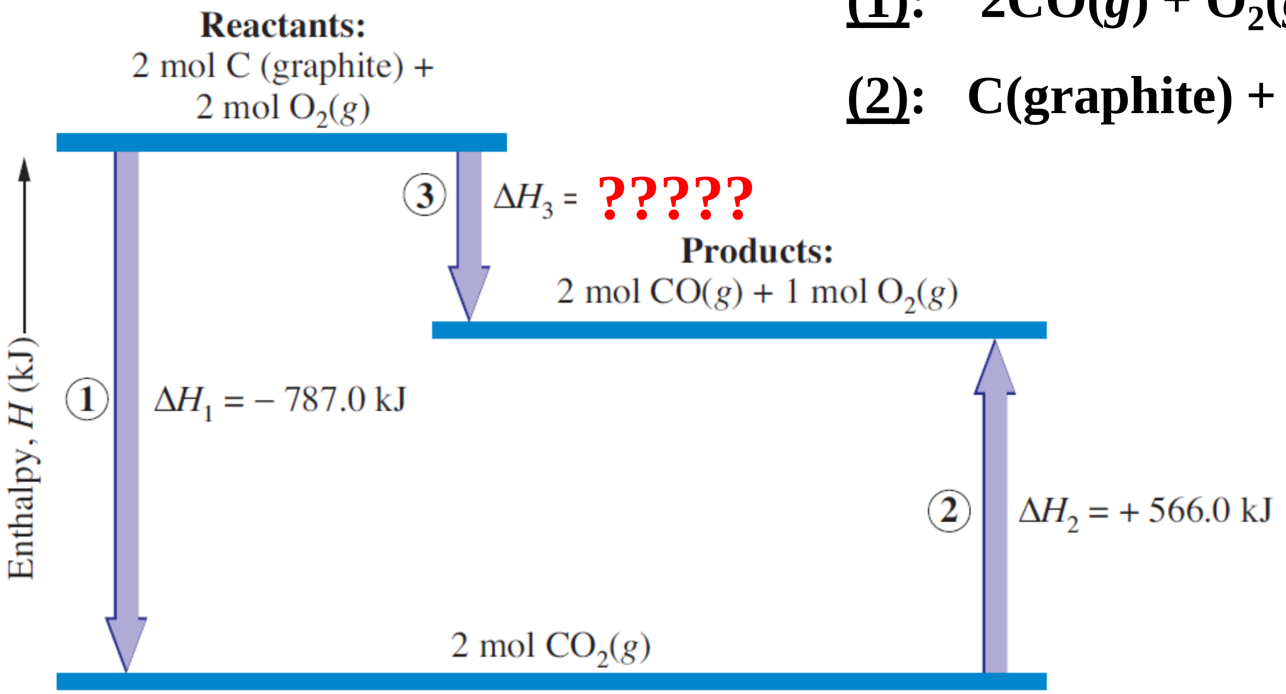
<u>(2)</u>: $C(graphite) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_2 = -393.5 \text{ kJ mol}^{-1}$

Hess's law of constant heat summation

Solution:

(1): $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$ $\Delta H_1 = -566\ kJ\ mol^{-1}$

(2): $C(graphite) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_2 = -393.5\ kJ\ mol^{-1}$



Enthalpy diagram illustrating Hess's law

The diagram shows two different ways to go from graphite and oxygen (reactants) to carbon monoxide (products). Going by way of reactions 1 and 2 is equivalent to the direct reaction 3.

Rate equation and rate constant

$$F_2\,(g) + 2ClO_2\,(g) \rightarrow 2FClO_2\,(g)$$

$$\text{rate} = k\,[F_2][ClO_2]$$

$$S_2O_8^{2-}\,(aq) + 3I^-\,(aq) \rightarrow 2SO_4^{2-}\,(aq) + I_3^-\,(aq)$$

$$\text{rate} = k\,[S_2O_8^{2-}][I^-]$$

Factors affecting Equilibrium Position

- Which of the following factors will affect chemical equilibrium?

1. Concentration change
2. Pressure change
3. Temp change
4. Involving a catalyst in reaction mixture