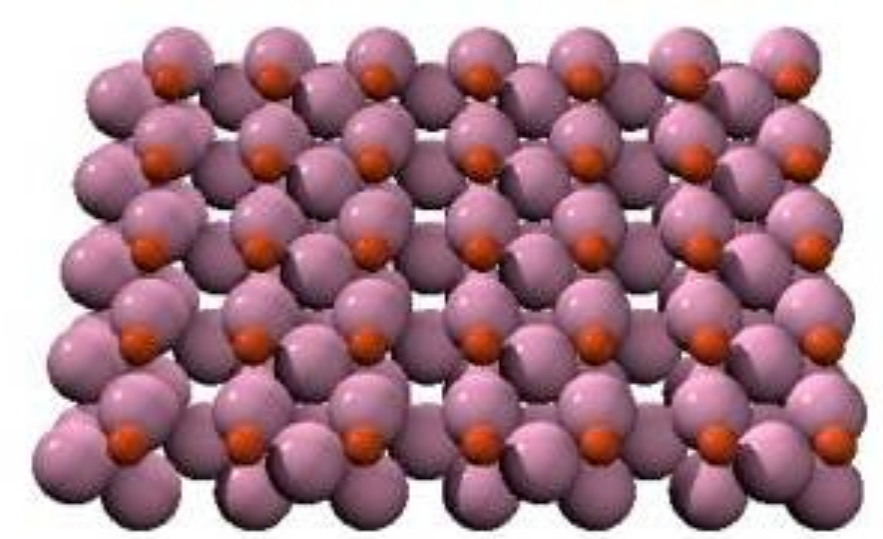
Adsorption of N_2 on Silica gel

Chem 381



Definitions

Adsorption:

when a fluid accumulated on a solid surface.

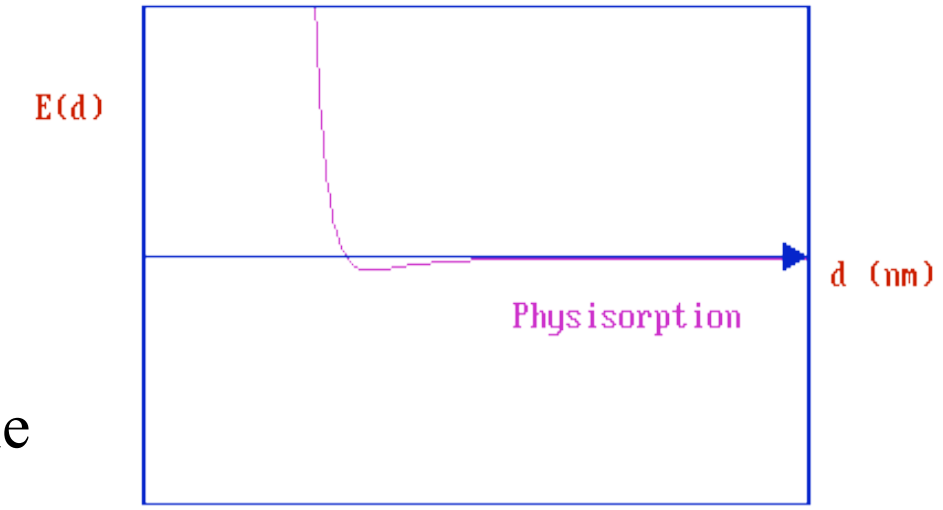
Isotherm:

line of constant temperature in a P vs. V plot, i.e., it is a measure of how much a adsorbent adsorbs as a function of Pressure at constant temperature.

Desorption:

The Reverse phenomenon of adsorption

Physisoprtion



PE Curve for Physisorption

❖ Reversible process

❖ Multilayer adsorption possible

❖ No chemical bond between the adsorbent and adsorbed species only van der Waal interaction

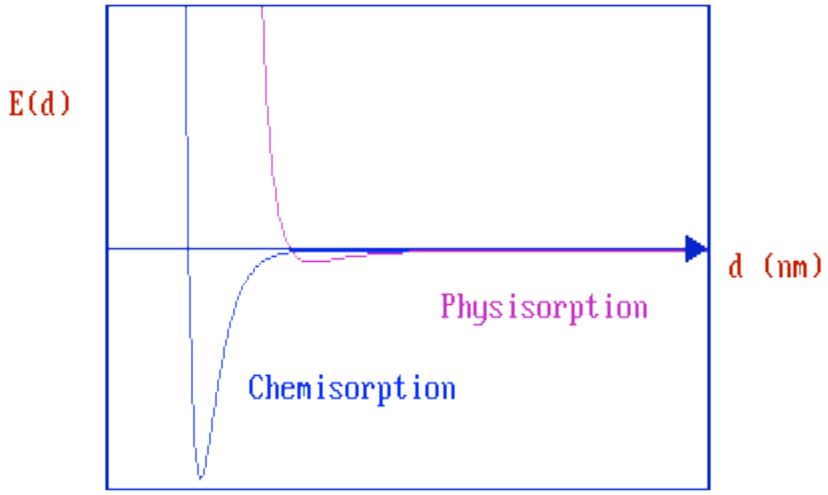
➢ **Examples:**

⇒ Adsorption on noble gasses on metal surface.

Chemisorptions

❖ May be Irreversible

❖ Monolayer adsorption



PE curve for Chemisorption

❖ Real chemical bond exists between adsorbent and adsorbed species

➢ **Examples:**

Adsorption of oxygen on copper surface.

Why interested in Adsorption

- Heterogeneous catalysis:

  $\Rightarrow$ Hydrogenation on Platinum surface.

- Catalytic Converters:

  $\Rightarrow$ Oxidizes CO and hydrocarbons.

- Adsorption Refrigeration:

  $\Rightarrow$ Methanol vapor on activated charcoal

Experiment

- Title:
  - ❖ Adsorption of N2 on Silica Gel
- Objective:
  - ❖ Fit the data with models like Langmuir and BET adsorption isotherm
  - ❖ To calculate the surface area of Silica Gel
  - ❖ To Calculate the heat of adsorption

Theory

❖Langmuir Adsorption Isotherm

- Basic Assumptions:

  ⇒ Monolayer adsorption.

  ⇒ No interaction among the adsorption sites.

  ⇒ Binding energy is same for all sites.

- Derivation:

$R_a = k_a P(1-\theta)N$

$R_d = k_d \theta N$

θ = fraction of sites covered

K_a = Rate constant of adsorption

K_d = Rate constant of desorption

N= Total number of sites

At equilibrium:

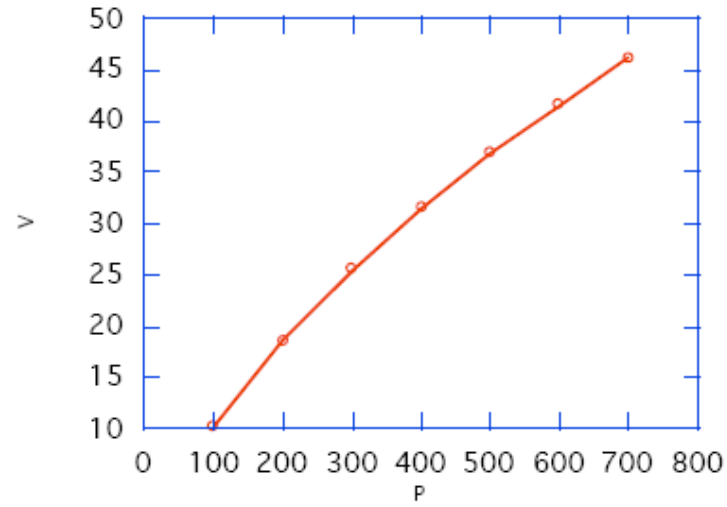
$$R_a = R_d$$

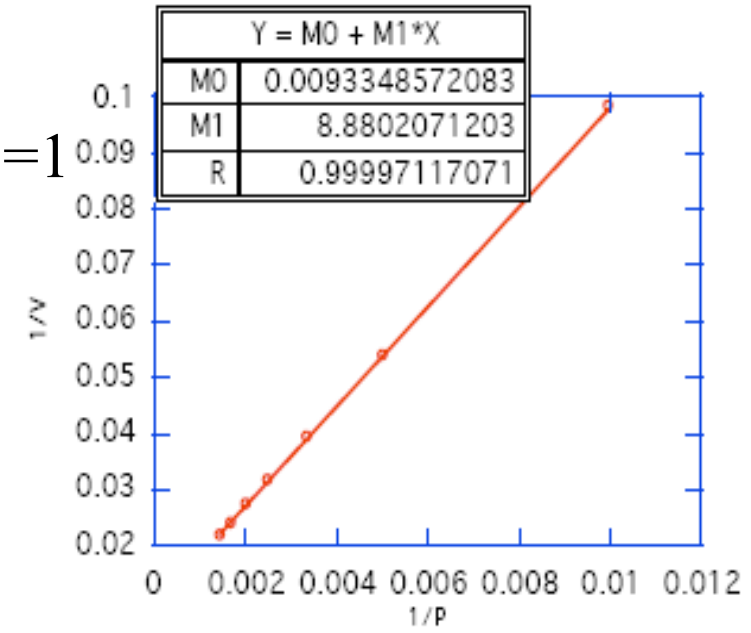
This leads to

$$\theta = KP/(1+KP)$$

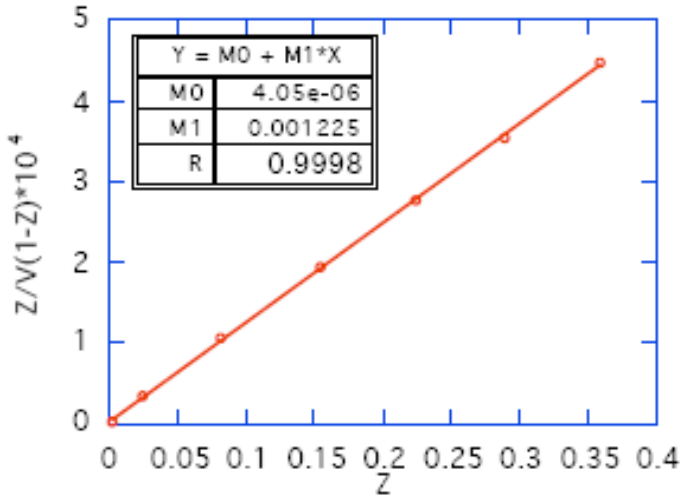
Putting $V\infty$= volume adsorbed for $\theta = 1$

$$V_\infty/V = \frac{1}{KP} + 1$$





❖ BET isotherm



➢ Basic Assumptions:

⇒ All sites are equivalent.

⇒ Multilayer adsorption is allowed.

⇒ No interaction between molecules in a layer

⇒ Molecules adsorbed on surface sites are localized.

➢ The isotherm:

$$\frac{Z}{V(1-Z)} = \frac{1}{cV_m} + \frac{Z(c-1)}{cV_m}$$

Where $Z = KP = P/P^0$; $c = P^0/P'$

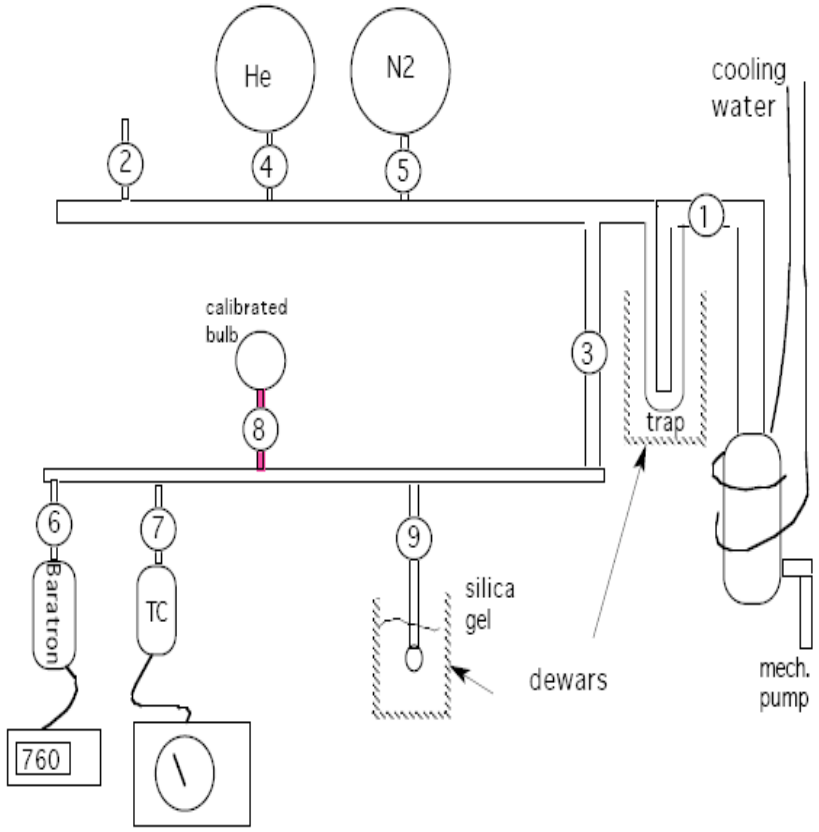
Procedure

1) Evacuate the Primary Manifold

2) Fill He and N2 in the Storage bulbs.

3) Determine the Volume of Secondary manifold and dead spaces with the He.

4) Get rid of the He from secondary manifold and pass N2 and measure the fall of pressure.



5) Calculate V_{man} , V_{ds}, and V_{dc} by using the simple relation

$$P_1V_1 = P_2V_2$$

6) Number of moles entering the bulb is given as

$$n_{sb} = n_i - n_{ff}$$

7) From the amount of N2 adsorbed, the surface area and heat of adsorption are calculated

Assignment

- Submit a Matlab Program to calculate the various parameters.

- Draw adsorption isotherms with the given data and do the error analysis

- Go through the derivation of BET isotherm

- Read instruction very carefully

Report

1) All the data you got.
2) Calculations of the volumes i.e., (V_{man}, V_{dstot}, V_{dsc} and V_{dsa})
3) Langmuir plot as well as BET plot
4) Surface area of Silica gel (meters/gram)
5) The heat of adsorption.
6) Error Analysis.

Safety

1) Safety glasses must be worn
2) The silica gel compartment should be evacuated before removal of liquid N2.
3) The valves should used with care.