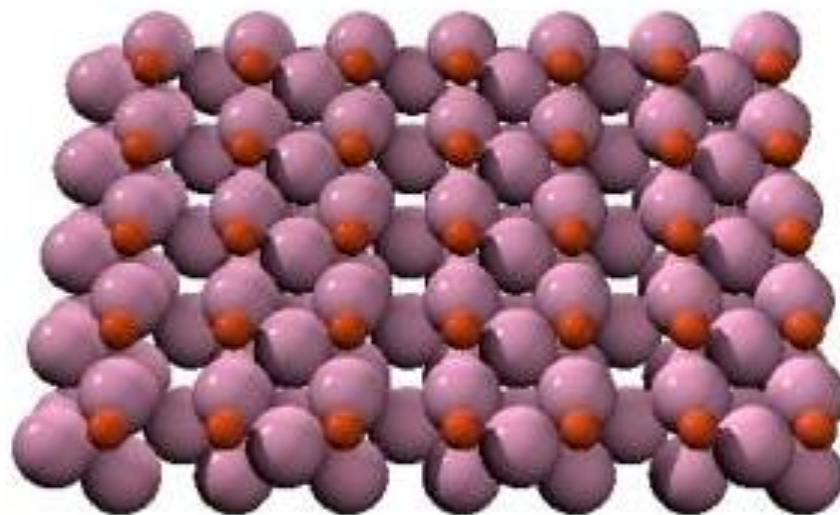


Adsorption of N₂ on Silica gel

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

Physisorption

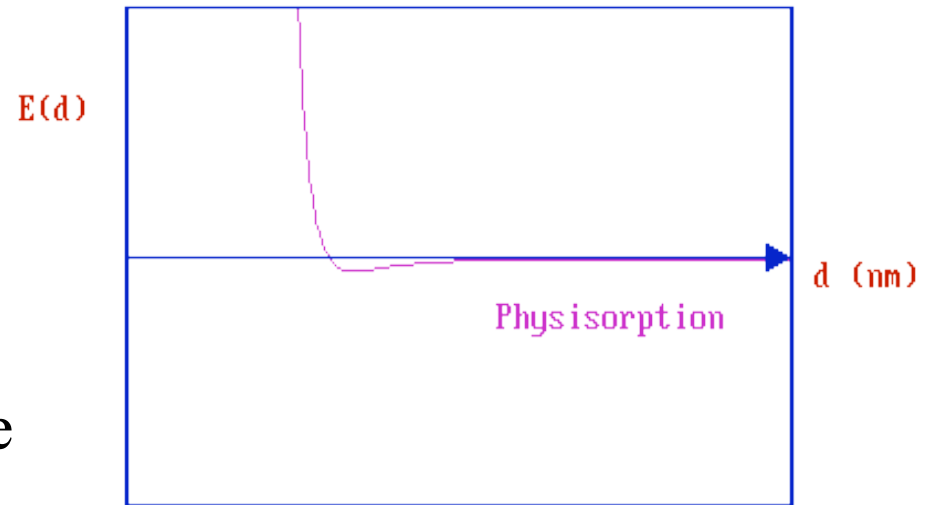
❖ Reversible process

❖ 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.

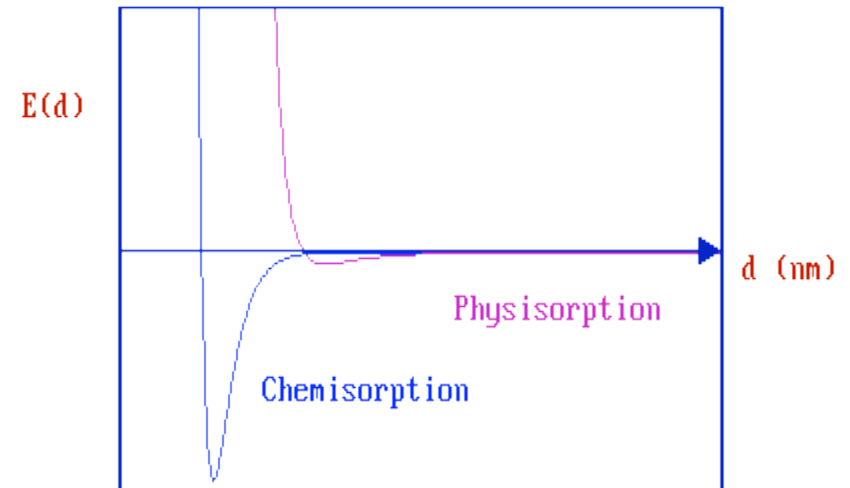


PE Curve for Physisorption

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:
 - ⇒ Hydrogenation on Platinum surface.
- Catalytic Converters:
 - ⇒ Oxidizes CO and hydrocarbons.
- Adsorption Refrigeration:
 - ⇒ 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:

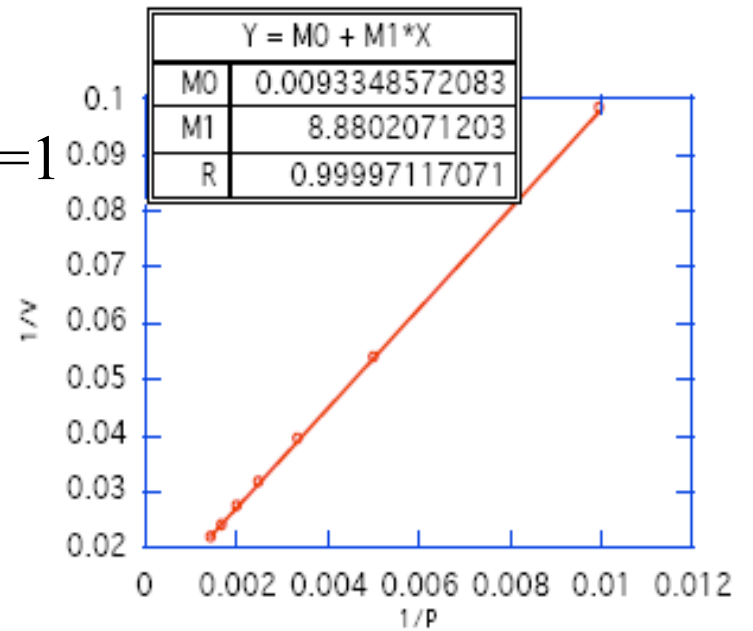
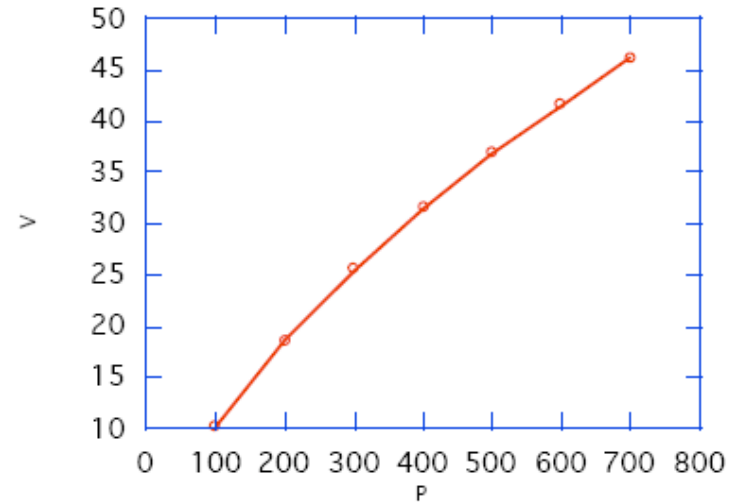
$$R_a = R_d$$

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.

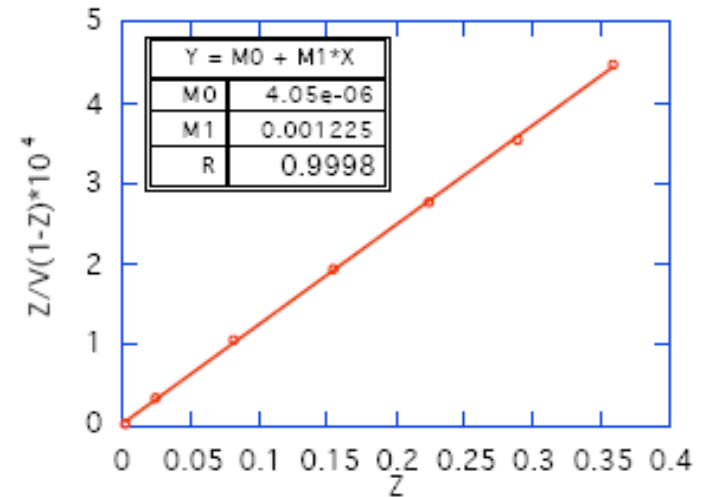
⇒ No interaction between molecules in a layer

⇒ Molecules adsorbed on surface sites are localized.

➤ The isotherm:

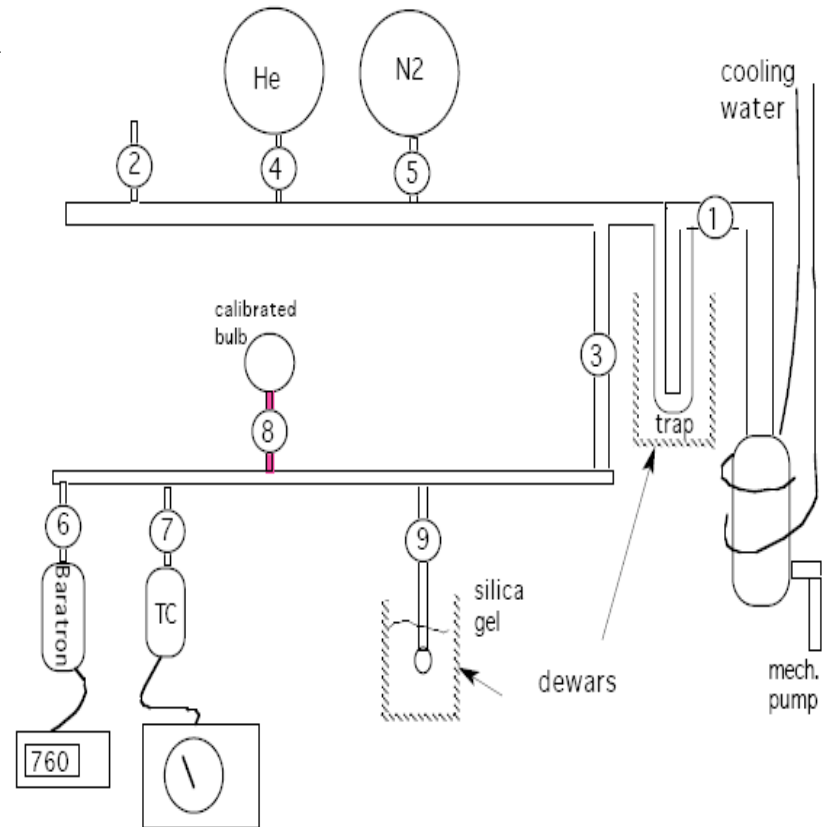
$$\frac{Z}{V(1-Z)} = \frac{1}{cV_m} + \frac{Z(c-1)}{cV_m}$$

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

$$P_1 V_1 = P_2 V_2$$

6) Number of moles entering the bulb is given as

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

7) From the amount of N_2 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 be used with care.