Chapter 3

part 1

properties of pure substances

* **pure substance** : that has a fixed chemical composition
  - ⇒ element ⟶ N, He,
  - ⇒ compound ⟶ , CO_2 , H_2O
  - ⇒ mixture ⟶ Air , mixture of ice and liquid water
    (homogeneous)

- oil/water mixture is <u>not</u> a pure substance
- liquid air/gaseous air is <u>not</u> a pure substance

* **phase** : having a distinct molecular arrangement that is homogenous throughout.
  solid / liquid / gas

- We are interested in the phase-change process espcially the change process from <u>liquid to vapor</u> and from <u>vapor to liquid</u> that takes place in many mechanical devices.

- **Compressed liquid** : subcooled liquid (it is <u>not</u> about to vaporize)

لا تزال المادة في هذه المرحلة سائلة بالكامل واي كمية
اضافية من الحرارة لن تحول اي جزء منها الى بخار

phase : liquid — Tempreture : ↑ — spe. volume : ↑

- **saturated liquid** : (it is about to vaporize)

المادة في هذه المرحلة سائلة، ولكن اي كمية
اضافية من الحرارة يتم ادخالها اليها سوف تجعلها
تبدأ بمرحلة التبخر اي تتحول جزء منها الى بخار

phase : liquid (but it will start vaporizing if we continee heating) — Tempreture : constant at a boiling temp. — spe. volume : if we contine heating it will increase

Saturated liquid-vapor mixture: (liquid and vapor coexist in equilibrium)

المادة في هذه المرحلة يكون جزء منها سائل و
الجزء الاخر بخار في وقت واحد

phase: liquid
vapor

temprature: constant

spec. volume: ↑

Saturated vapor: (That is about to condense)

المادة في هذه المرحلة تكون كلها بخار واي كمية من
الحرارة يتم سحبها من المادة ستعود المادة الى mixture
وتبدأ مرحلة التبخر اما اذا اضفنا اليها حرارة
سترتفع درجة حرارة البخار

phase: vapor

temprature: constant.

spec. volume: if we continue heating it will increase

Super heated vapor: (it is not about to condense)

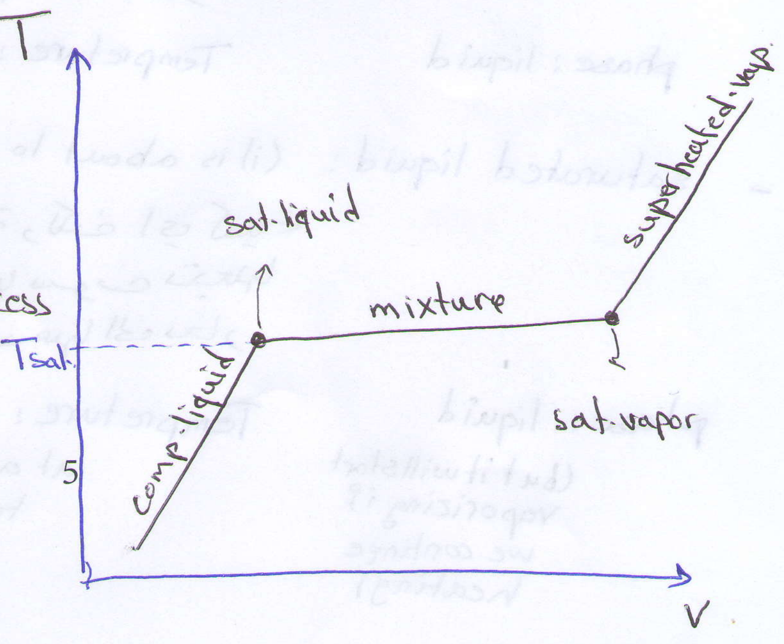
المادة في هذه المرحلة تكون بخار واضافة الحرارة
لها ستسبب ارتفاع درجة الحرارة

phase: vapor

but it will still vapor even if cool it → until it goes back to the sat. vapor

temprature: ↑

spec. volume: ↑



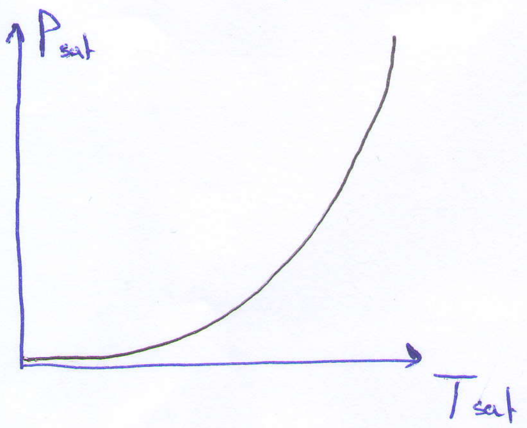
* All this changing process happen at constant pressure

$T_{saturated}$: درجة الحرارة التي يحدث عندها تغير في حالة المادة (phase) عند ضغط (pressure) معين

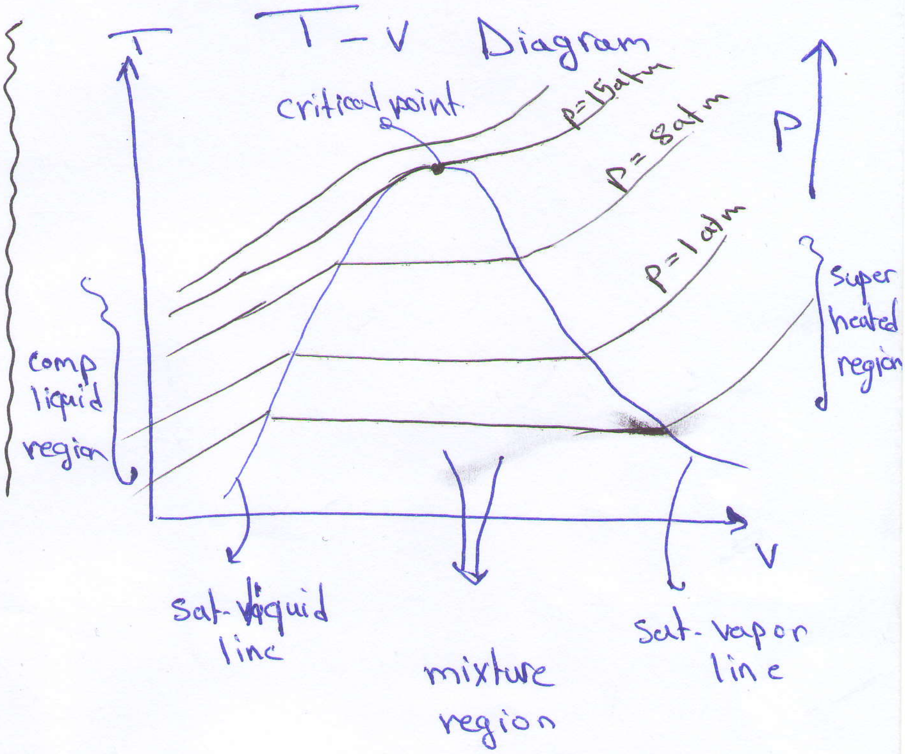
$P_{saturated}$:

الضغط الذي يحدث عنده تغير في حالة المادة (phase) عند درجة حرارة معينة

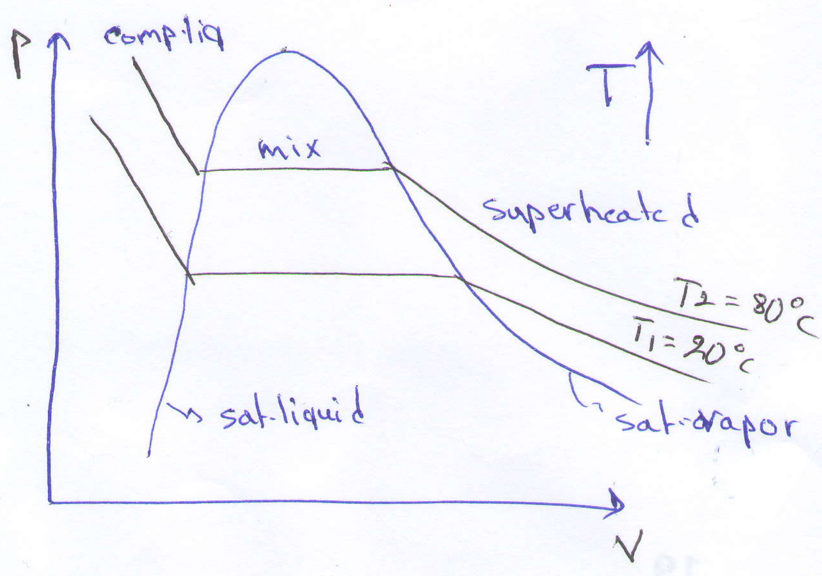
علاقة الـ T ، P



T – v Diagram



P – v Diagram



* critical point:
which sat.liq. and sat.-vap. are identical

اي ان الانتقال من السائل الى البخار يحدث مرة واحدة دون المرور بمرحلة الـ (mix)

* **Enthalpy :** Combination of properties.

$$\rightarrow \quad h = \underbrace{\underset{\substack{\downarrow \\ \text{property}}}{\overset{\text{internal}}{u}} + \underset{\substack{\downarrow \\ \text{property}}}{\overset{\text{flow work}}{Pv}}}_{\text{combination}}$$

- we use enthalpy in the analysis of power generation and refregeration

- How to deal with Tables ??

* sat. liquid / Sat. vapor :

- We use Table
  - A-4 → when temperature is given } water
  - A-5 → " pressure " "
  - A-11, A-12 } Refrigerant -134a.

- for a given T we have a corresponding P_{sat}.
- " " " P " " " " T_{sat}.

v_f, h_f, u_f, s_f → for saturated liquid

v_g, h_g, u_g, s_g → for saturated vapor

$v_{fg}, h_{fg}, u_{fg}, s_{fg}$ → for the difference (g-f)

** h_{fg} → enthalpy of vaporization (the amount of heat (energy) needed to vaporize a unit mass of sat. liquid at a given T or P)

* **Sat. mixture :**

- in the mixture T and P are dependent so we need another property

* quality X : $X = \dfrac{m_g}{m_{Total}}$, $m_{Total} = m_f + m_g$

- we use quality (x) with mixtures only

$$\left\{ \begin{array}{l} y_{avg} = y_f + X y_{fg} \\ X = \dfrac{y_{avg} - y_f}{y_{fg}} \\ y \rightarrow h, s, u, v \end{array} \right.$$

$0 \leq X \leq 1$

↓ sat. liq ↓ sat. vap.

- We know that we are in the mixture region if

$y_f < y_{avg} < y_g \longrightarrow$ mixture

$y_{avg} = y_f \longrightarrow$ sat. liq

$y_{avg} = y_g \longrightarrow$ sat. vap.

* Superheated vapor:

- If $T_{given} > T_{sat}$ or $P_{given} < P_{sat}$

$\Downarrow$ superheated.

* we check on T_{given} or P_{given} or $y(u, h, v, s)$ in tables A-4 / A-5 Then we go to table A-6 to get the superheated properties

- If $y > y_g \longrightarrow$ superheated.

$u, h, v, s.$

* Compressed liquid:

- we treat compressed liquid as saturated liquid at the given temperature

note: $\cancel{y = y_{f@P}}$

step ② - $y = y_{f@T}$

$\Rightarrow$ for h : $h = h_{f@T} + v_{f@T}(P - P_{sat@T})$

step ① - If $T_{given} < T_{sat}$, $P_{given} > P_{sat}$

$\Downarrow$ compressed liquid

- If $y < y_f \longrightarrow$ compressed liquid.

$u, h, v, s.$

* we use the tables A-4 / A-5 to get the compressed liquid properties.

* In Thermodynamics we are concerned with the changes of proprties not in single values.

** Note: We find $T_{critical}$, $P_{critical}$, $V_{critical}$ in Table A-1