# Strategy to Determine the Phase of a Chemical Mixture

If the problem statement gives the phase of a mixture, then you label that phase in the conceptual model.

What do you do when the problem statement does not give the phase of the mixture? Well, you have to determine it using the temperature ($T$), pressure ($P$), and composition ( $\bar{Z}$ or mole fractions) of the mixture.

**Given:** $T, P, \bar{Z}$ *where* $\bar{Z}$ *means* $z_1, z_2, \cdots, z_{nc}$ **Find:**… *Ph or phase*

$nc$ is the number of components

## Pure-Component Mixture ( $nc = 1$, a pure compound )

For $P$ = 1 atm, find $T_m$ and $T_b$ in Table B.1 of F&R, 3rd Ed.

If $T > T_b$, then $Ph$ = vapor — where $T_b$ is the boiling point
If $T = T_b$, then $Ph$ = vapor-liquid

If $T_m < T < T_b$, then $Ph$ = liquid

If $T < T_m$, then $Ph$ = solid — where $T_m$ is the melting point
If $T = T_m$, then $Ph$ = solid-liquid

For $P \neq$ 1 atm, find $T_b$ using Antoine Equation in Table B.4 of F&R, 3rd Ed.

If $T > T_b$, then $Ph$ = vapor
If $T = T_b$, then $Ph$ = vapor-liquid
If $T < T_b$, then $Ph$ = liquid

## Multi-component Mixture ( $nc > 1$ )

note: $T_{c,j}$ is the critical temperature of $j$.

**Case 1:** $T \geq T_{c,j}$ for each $j$ in the mixture, then $Ph$ = gas or supercritical fluid

**Case 2:** $T \geq T_{c,j}$ for most $j$ in the mixture then have a one-condensable system and
$T < T_{c,j}$ for one $j$ in the mixture then check $T_{dp}$ of the mixture

Raoult's Law: $z_j P = P_j^*$ *and* $T_{dp} = tsat[P_j^*]$
where *tsat* is the Antoine Equation in Table B.4 of F&R, 3rd Ed.

If $T > T_{dp}$, then $Ph$ = vapor — where $T_{dp}$ is the dew point.
If $T \leq T_{dp}$, then $Ph$ = vapor-liquid

**Case 3:** $T < T_{c,j}$ for each $j$ in the mixture, then check $T_{dp}$ and $T_{bp}$ of the mixture

Raoult's Law: $\left[T, \bar{X}, \bar{Y}\right] = vlet\left[P, V_f, \bar{Z}\right]$ see Page 6-15 in *CinChE*.

$T = T_{dp}$, when $V_f = 1$
$T = T_{bp}$, when $V_f = 0$

If $T > T_{dp}$, then $Ph$ = vapor — where $T_{dp}$ is the dew point.
If $T < T_{bp}$, then $Ph$ = liquid — where $T_{bp}$ is the bubble point.
If $T_{bp} \leq T \leq T_{dp}$, then $Ph$ = vapor-liquid

Note that function ***vlet*** can be represented by a table, graph, equations, or computer program like HYSYS. In HYSYS, place and define a process stream on the flowsheet to find $T_{dp}$ and $T_{bp}$.