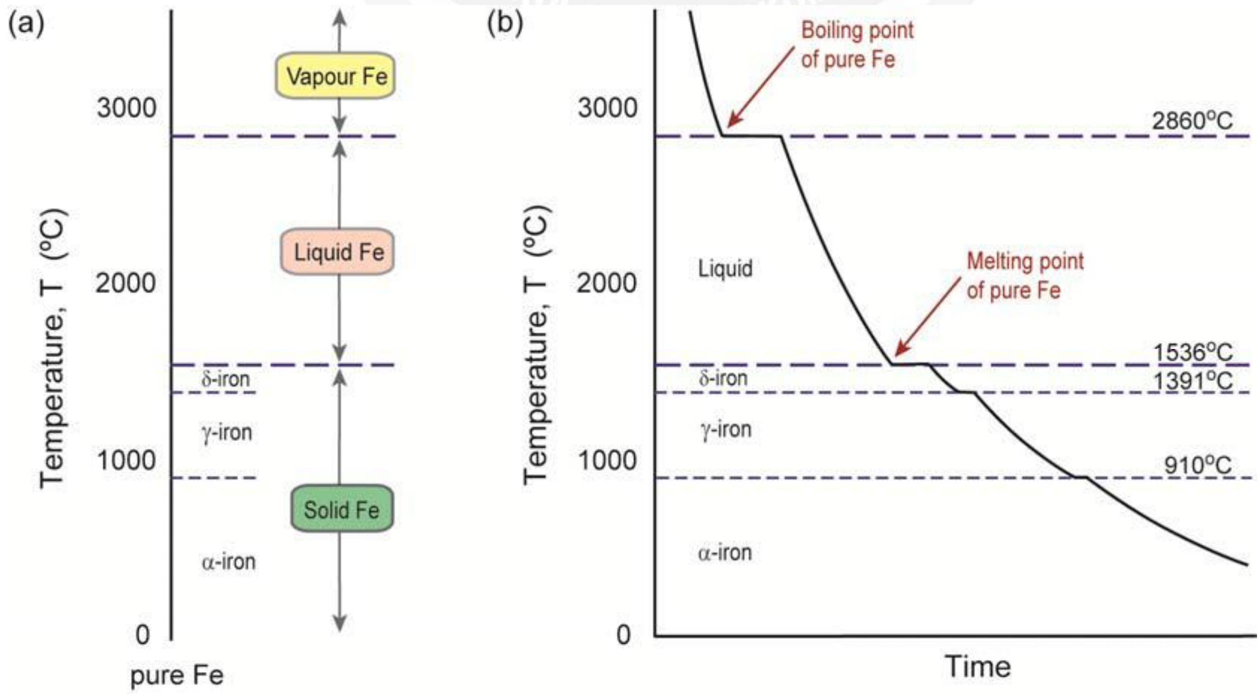
One component system

- ❖ A single component system is one which has no composition variable.
- ❖ It is also known as pressure-temperature or P-T diagram.
- ❖ The simplest phase diagram is the water which is a one component system.

Single component phase diagrams (Unary)

One-component system of iron

- ✓ Consider first a pure material is heated from the solid state. The melting temperature is the unique temperature at which the phase change to the liquid state occurs, and solid and liquid can co-exist in equilibrium. Similarly, liquid changes to vapour at a unique (higher) temperature, the boiling point.
- ✓ Pure iron (Fe) is a single component system and there is no composition variable. The pressure is plotted on the X-axis and temperature on the Y-axis. Therefore this phase diagram is called PT unary phase diagram Apart from the liquid and gaseous phases many solid phases ($\alpha, \gamma, and\, \varepsilon$) are possible based on crystal structure.



: (a) one-dimensional phase diagram for pure iron; (b) Cooling curve of a pure iron

The Gibbs phase rule for one component system is

F = C – P + 2 (2 is for T & P)

- .Let us first consider the single phase regions on the diagram such as gas, liquid and several crystal forms of iron. Here C=1 and P=1 and phase rule becomes

$$F = C - P + 2 = 1 - 1 + 2 = 2.$$ **(Two degrees of freedom)**

- This result tells that there is two degrees of freedom, and thus two variables (T and P) can be changed independently and the system will remain a single phase.
- When two phases are in equilibrium, C= 1 and P=2. Thus from Gibbs phase rule,

$$F = C - P + 2 = 1 - 2 + 2 = 1$$ **(One degrees of freedom)**

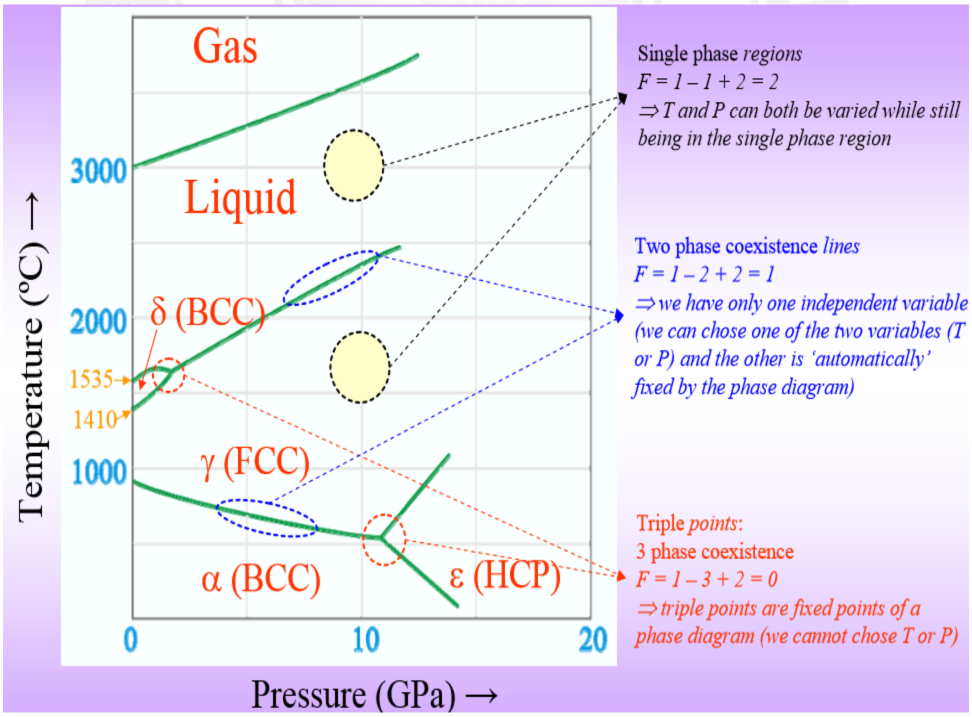
- This result reveals that there is one degrees of freedom, and thus one variable (T or P) can be changed independently and still maintain a system with two coexisting phases (phase boundaries).
- At the triple point, three phases coexist in equilibrium, and since there is one component in the system (iron), the number of degrees of freedom is given by

$$F = C - P + 2 = 1 - 3 + 2 = 0$$ **(Zero degrees of freedom)**

- At only one particular combination of pressure and temperature, three phases will coexist. If we change pressure or temperature from the fixed triple point value, one or two phases will appear.
- First, we consider pure iron. Figure 2.5a shows the phases found in pure iron. The low temperature form of iron is called ***ferrite*** (or α-iron), which has a body-centred cubic (BCC) lattice. On heating pure iron changes to ***austenite*** (or γ-iron) at 910ºC, and switches to a face-centred cubic (FCC) lattice. Pure austenite is

stable up to 1391ºC, when it changes back to BCC δ-iron, before melting at 1536ºC, and boiling at 2860ºC.

- ✓ Above 1536ºC, pure iron is in molten form (melting point). It solidifies initially to BCC δ-iron, but undergoes further solid-state phase transformations on cooling, first to FCC γ-iron at 1391ºC, and then back to BCC α-iron at 910ºC. At 910ºC, another phase occurs from FCC non-magnetic α-iron into BCC non-magnetic α-iron. Finally at 768ºC, α-iron becomes magnetic without a change in lattice structure.
- ✓ When pressure is increased, the $\alpha \rightarrow \gamma$ transition temperature is lowered, whereas the $\gamma \rightarrow \delta$ transition temperature is increased. If applied pressure of 15 GPa at room temperature, the BCC α-iron transforms to the HCP ε-iron phase. The cooling for pure iron showing allotropic changes is shown in figure 2.6.



One-component system of iron