चौधरी PHOTOSTAT

"I don't love studying. I hate studying. I like learning. Learning is beautiful."

"An investment in knowledge pays the best interest."

Hi, My Name is

METALLURGY

for GATE/IES

(Career Evenues)

S. S. Vijetha (1)

Thermodynamics

Heat Transfer

Mass transfer

Electrochemistry

Corrosion

Momentum Transfer

15 yrs. GATE papers

Test Series

Workbook

Book

} Sum. from

GATE MATRIX:

Gate Weightage (first 10 years) = 15 - 17% approx

No of 1 mark questions → (4-5)

No of 2 mark questions → (5-6)

Gate syllabus	Marks
Thermodynamics	6-7
Electrochemistry & Corrosion	3-4
HT	2 (num)
Mass transfer	2-3
Momentum transfer	2-3

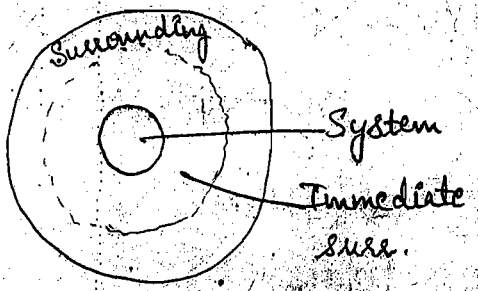
Books

- Nirodha Ghosh
- Gaskell

Thermodynamics: It is the branch of energy (Q, W) interaction and its effect on the system and the surrounding

- Sign convention is very important

System: It is defined as a quantity of matter or a region in space where our study is focussed.



Surrounding: The mass or region outside the system is called as surrounding.

The part of the surrounding which is affected by the system is called as immediate surrounding.

Types of system	Mass transfer	Energy transfer	Exp.
1. Open system	✓	✓	Piston cylinder arrangement with valves
2. Closed system	X	✓	Piston cylinder arrangement without valves
3. Isolated system	X	X	A perfectly insulated thermos containing hot coffee. - Universe

★ PROPERTIES OF THE SYSTEM:

→ Any characteristics of the system is called property of the system. The properties can be classified as:

1. Intensive / Intrinsic:

The properties which are independent of the mass or no of moles of the system.

Ex: Pressure, Temperature, Density, etc.

2. Extensive / Extrinsic:

The properties which depend on mass or no of moles of the system.

ex: total energy, total volume, enthalpy, Internal energy, entropy, etc.

Note: All specific prop's are Extensive prop's.

Ex: Specific volume, Specific internal energy, specific enthalpy etc.

2015 Im Which of the following prop's is intensive?

(a) Volume (b) Gibbs free energy

(c) Chemical potential (d) Entropy

$\mu = \frac{dG}{dn}$ ← Molar Gibbs free energy

* Imp points w.r.t prop's:

1. Prop's are point function or state function.
2. Prop's are exact differentials.

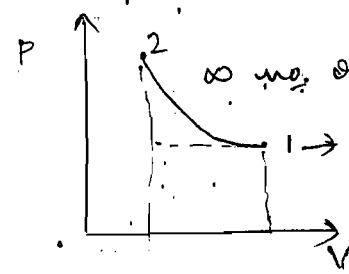
$$\int_1^2 dx = x_2 - x_1$$

(Enexact)

$\delta \Rightarrow$ small change
$d \rightarrow$ exact
$\Delta \rightarrow$ large change

3. Independent of past History.

* Definitions:

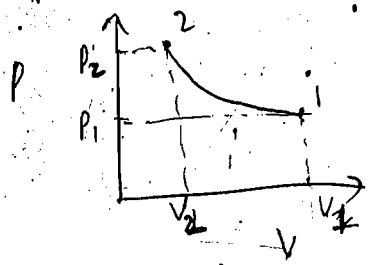


∞ no. of states through which system passes

1 → state of the system

Any condition of the system is called as the state of the system and the state of the system is specified by its properties. If any one of the prop changes, the state of the system changes.

→ The infinite state through which a system passes while moving from an initial state to final state is called as ~~process~~ PATH and change in state is called as process.



PHYSICAL METALLURGY

10-9-18

GATE matter:

Book:

Gate weightage - (18 - 22 marks)

no of 1 m qns : 5-8

no of 2 m qns : 5-8

- V. Raghavan
- Callister

Properties:

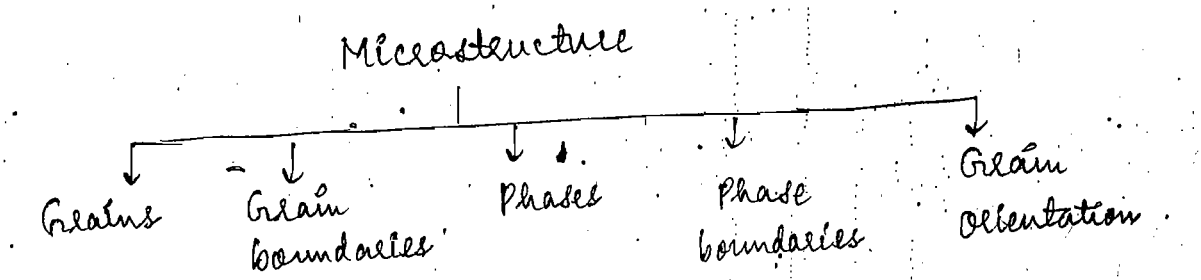
These are defined as quantitative indices of response of a material when subjected to external stimuli.

Structure:

The three important structures that we come across in material science are:

1. Microstructure:

It is defined as the internal structure and details of the material which can be observed by the microscope under higher magnifications of the order of more than or equal to 100 X ($\geq$ 100X).



2. Macrostructure:

It is defined as external geometrical characteristics of a material which can be observed at lower magnifications of the order of less than 100 X (< 100X).

3. Crystal structure:

Crystal structure can be described in terms of a 3D periodic arrangement of points called lattice and an atom or group of atoms associated with each lattice point called Motif.

Engineering materials:

Crystalline materials	Amorphous materials
→ These are those materials which exhibit 3D long range periodicity of arrangement of atoms or molecules or ions. The crystallinity can be seen in metals, many ceramics and some polymers.	→ Atoms have no periodic packing. → occurs for: Complex structure Rapid cooling Ex: Fiber glass, Teflon, PVC, etc.

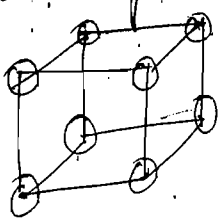
Important Definitions:

Unit Cell: A unit cell is defined as a smallest representative of a group of atoms which when repeated in all the crystallographic directions for infinite number of times results in the development of a crystal lattice.

Crystal lattice: It is defined as 3D network of lines in space. It is also called as a 'line lattice'.

Space lattice: It is defined as 3D network of points in space and it is also called as point lattice.

Primitive Cell: It is defined as a simple cubic unit cell having atoms only at the 8 corners.



Allotropy: It is defined as the tendency of an element to exist in different crystalline structures at different temperature & Pressure.

Ex: Fe, C, etc.

Crystal systems:

Based on XRD technique, all crystalline materials are classified into 7 crystal systems. These crystal systems are further classified into 14 Bravais Lattices.

Crystalline materials

↓

7 crystal system (depending on shape)

↓

14 Bravais lattices (based on Atomic arrangement)

S. Vijetha (1)

Extractive Metallurgy

$$\pi d^2 \times h_1 = \pi D^2 \times h_2$$

$$h_1 = h_2$$

$$\frac{\Delta h_1}{h_1} \times 100 = \frac{\Delta h_2}{h_2} \times 100$$

$$\Delta h_1 = x\% \times 100 \quad h_2 = y \times 100$$

$$h_1 - h_2 = x\% - y$$

Extractive Metallurgy

1. Ore Dressing:

Ore: Naturally occuring solid material from which a metal or metallic values can be extracted.

Mineral: naturally occuring inorganic compound. ex: Rutile.

Ore have atleast 2 kinds of mineral in it.

Gangue: waste particles. Ex: SiO_2, Sodium Aluminate ($NaAlO_2$)

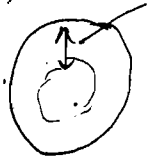
Ore consists of mineral and gangue.

→ **Mineral of Economic Importance**

- → % metal present in an ore / mineral
- → % impurities " "
- → Transportation charges
- → Land cost & rehabilitation cost
- → form of ore (physical)

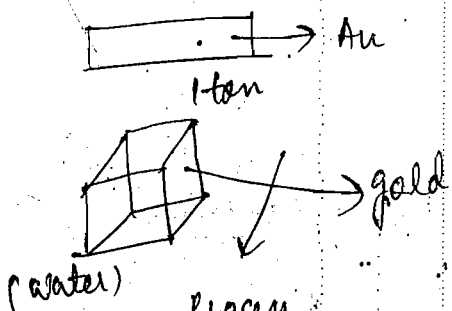
→ **Sources of ore**:

- → Earth crust
- → Ocean



Most abundant element in earth crust – O_2

Most abundant metal in earth crust – Al



South America & ~~Mines~~
South Africa & Au mines.

1-ton ore - 12-18 gms

India - Kolar & - 6-8 gms
Hutti &
(1-ton)

Ore dressing:

Processes which includes several methods to ~~obtain~~ yield marketable products.

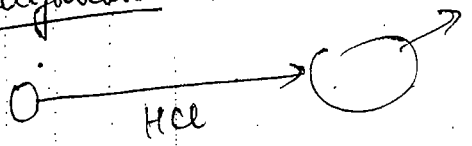
Processes in which we do not change ~~the~~ any chemical properties is called unit operation.

Ex: Crushing, Grinding

Any process in which we change the chemical prop's of the ore. is called unit processes.

Ex: (1) $FeO \xrightarrow{O_2} Fe_3O_4, Fe_2O_3$
(Fe_3O_4 - magnetic)

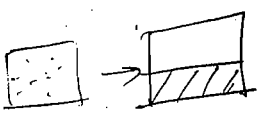
(2) Chloridization



The one which is more chloridized will go out of solution.

GATE 2007
Identify incorrect statement wrt unit processes.

(a) Crushing, grinding
~~(b)~~ Coal → coke
(c) Pptn in hydrometallurgy
(d) ~~classification~~ sorting, sizing.



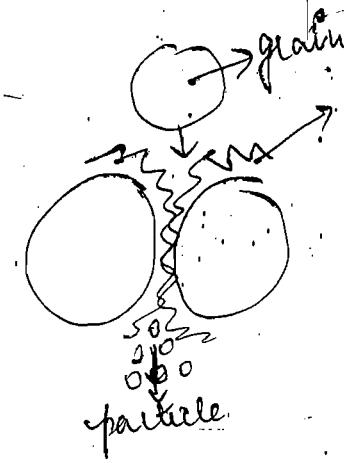
ORE DRESSING / BENEFICATION

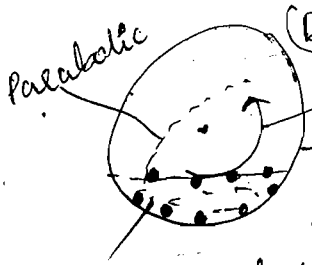
1. Communition (reducing size)

(a) crushing : Ex: Jaw Crusher, Gyratory grinder.

(b) grinding < 6 mm : Ex: Ball mill, Pebble mill, rod mill

Ex:

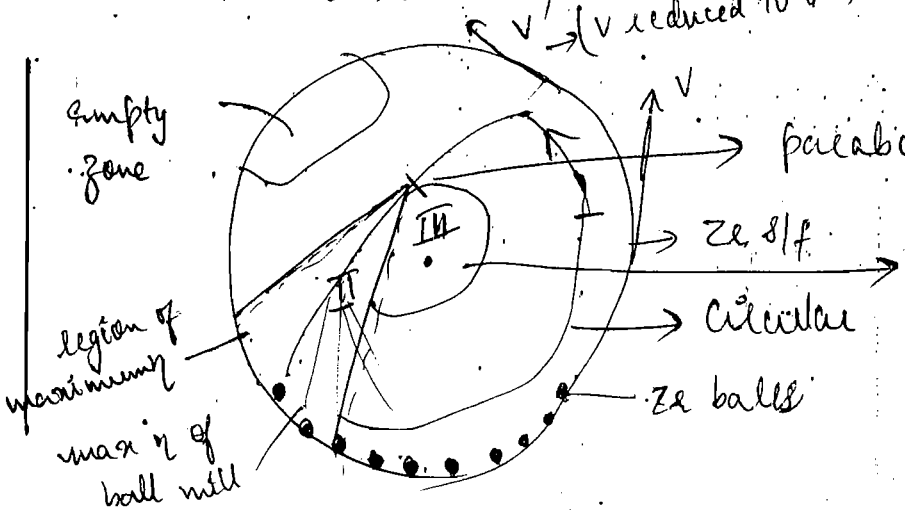




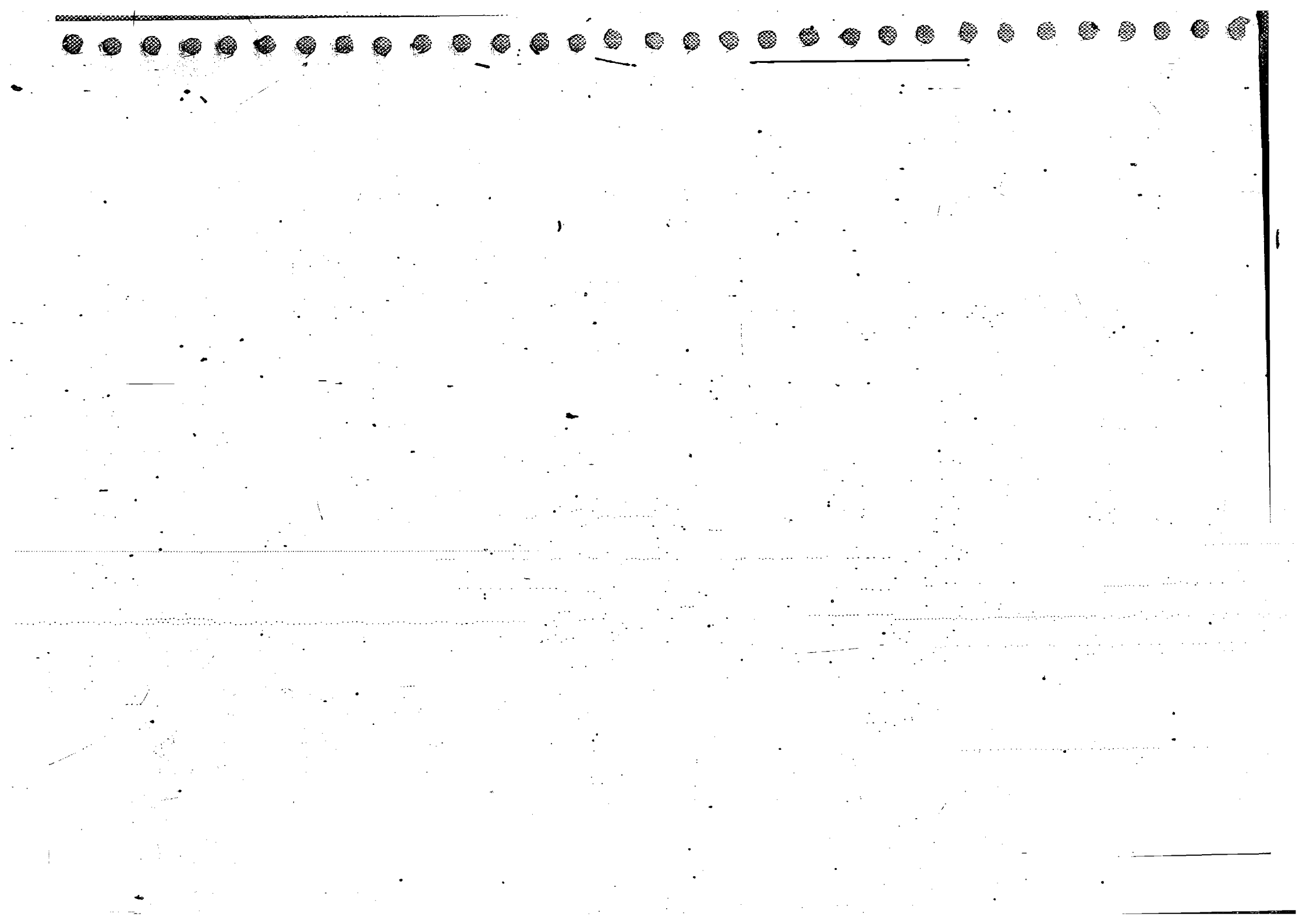
any hard material (Ze, Steel, Mn, W)
↓
• balls
(< 2cm dia)

Charge material

• → ○
• → ○ → •
• → • × (reduce lifetime of Ze balls)
○ → ○



Manufacturing Processes



Manufacturing processes (12-14 marks)

- Casting
- Welding
- Metal forming
  - Rolling
  - forging
  - Drawing
  - Extension
- Powder metallurgy
- NDT

CASTING: (3-4 marks)

Definition: It is a process in which molten liquid metal will be allowed to solidify in a predefined mould cavity. After the solidification, by breaking the mould, the object will be taken out. This is known as casting.

Advantages of casting:

1. Complex shapes can be easily produced.
2. Tools used in this technique are less expensive when compared to other processes.
3. Any type of material can be easily casted, ie, hard or soft, ductile or brittle.
4. Large sized objects can be produced by casting only (200-250 ton)
   ex: road rollers, gear housing, m/c tool beds, etc.

Limitations:

1. S/f finish of castings are very poor (sand moulding technique)
2. It is a laborious and time consuming process (sand moulding technique).
3. Poor dimensional accuracy (due to shrinkage).

4. Casting components are not having uniform chemical prop's throughout its cross-section.

Pouring temp (T_p):

$T_p = T_m + \Delta T$ → Degree of superheat

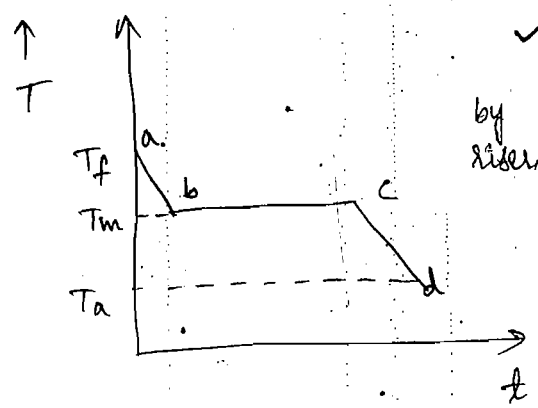
ex: for Al – 150° superheat

for Cu – 250° due to high thermal conductivity.

Pattern:

- It is the replica of the object to be made with some modifications.
- The modifications are in the form of Allowances and Core print allowances

(a) Shrinkage allowance or Contraction allowance:



✓ for a pure material

by riser ← [a-b : liquid shrinkage
b-c : solidification shrinkage

c-d : solid shrinkage
↓
compensated by pattern

- Both liq and solidificatn shrinkage can be compensated by providing riser and these values are expressed in terms of % of shrinkage volume of the casting.
- Solid shrinkage is compensated by shrinkage allowances. Solid shrinkage will be expressed in terms of linear dimensions only. These values will be added for the linear dimensions of the casting while design of the pattern.

$$\delta l = \alpha \, l \, \Delta T$$

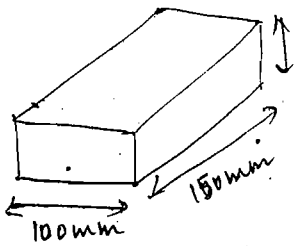
α → linear expansivity coeff.

for solid shrinkage

→ Shrinkage values for diff materials:

1. Bismuth → negligible
2. Cast Iron → 10mm/m
3. Al → 13 mm/m
4. Brass → 15 mm/m
5. Cu → 17mm/m
6. Steels → 20mm/m
7. Zn → 24 mm/m

Q) Design a pattern for casting shown below if it is produced by solid material by considering shrinkage allowance.



→ Allowance - 20mm/m → per 1000 mm → 20mm

(i) $\frac{100 \times 20}{1000} = 2$; $100 + 2\text{mm} = 102\text{mm}$

(ii) $150 \times \frac{20}{1000} = 3$; $150 + 3\text{mm} = 153\text{mm}$

(iii) $\frac{80 \times 20}{1000} = 1.6$; $80 + 1.6 = 81.6\text{mm}$

Q) A cubical casting of 50mm size is having volumetric solidifn shrinkage of 4% and volumetric solid contraction of 6%. There is no risers used and pattern making allowance is not considered. What is the final size of the casting in mm.