ESO 205T

Nature and Properties of Materials

Interaction session: 11-12 Monday
Tutorial: 11-12 Thursday

Assignment 7

Due by 12 November 2020 11 am

Question 1

The Canadian prairies are the granaries of the world and experience beautiful spring, summer and fall followed with a very harsh winter when the night temperature falls to -30 degree Celcius. Can you comment on the strategy adopted by the City administration to reduce ice on roads and sidewalks?

Also, comment on the strategies adopted to provide drinking water in such harsh winters.

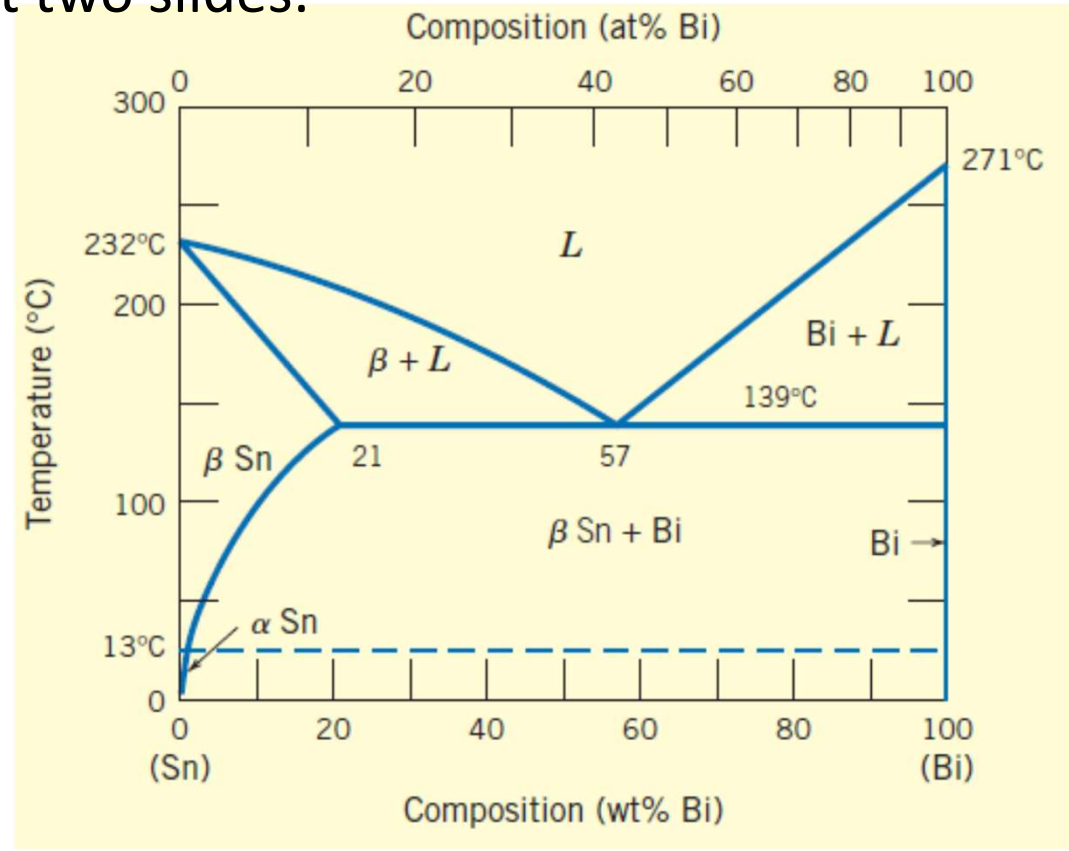
Question 2

Derive the Lever rule.

Determine the microstructure in terms of phases present and their relative amount (fraction) for the three important reactions in the iron carbon phase diagram at room temperature and 1000 ˚C.

Question 3

There is a push to develop lead free electronics as it is carcinogenic in nature and Sn-Bi eutectic is a candidate solder material. Refer to the Sn-Bi phase diagram to answer questions on the next two slides.



Question 3

A tin-bismuth alloy of composition 30 wt.% Bi–70 wt.% Sn is slowly heated from a temperature of 50 °C

(a) At what temperature does the first liquid phase form?

(b) What is the composition of this liquid phase?

(c) At what temperature does complete melting of the alloy occur?

(d) What is the composition of the last solid remaining prior to complete melting?

Question 3

(e) For a lead–tin alloy of composition 80 wt.% Bi–20 wt.% Sn at 139 °C:

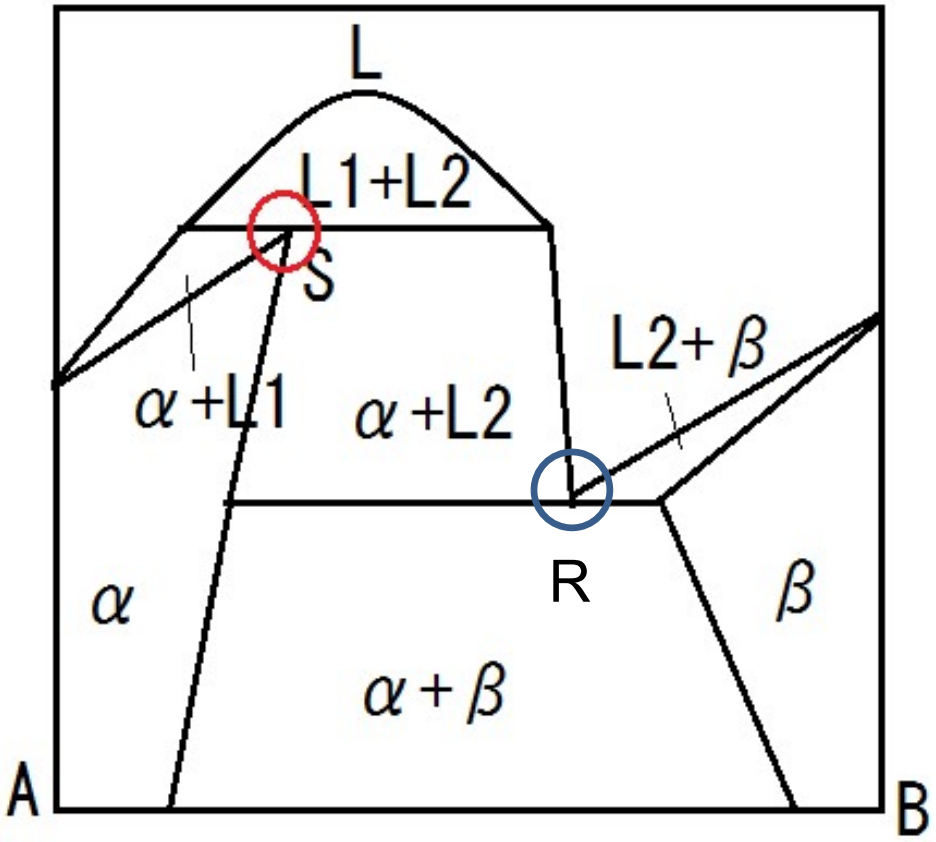
(i) Determine the phases that are present with their relative amount

(ii) Determine the mass fractions of primary Bi and eutectic micro-constituents

Question 4

(a) Determine the degrees of freedom at points R and S in the phase diagram below.

Temperature



Question 4

(b) Determine the degrees of freedom at points R, S, T and E in the projection of a ternary eutectic in a ternary phase diagram.

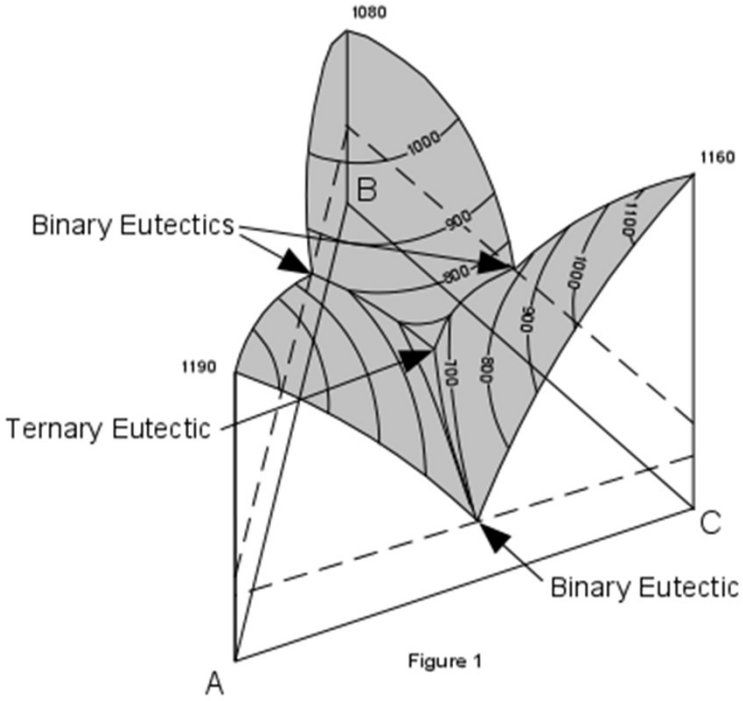


Figure 1

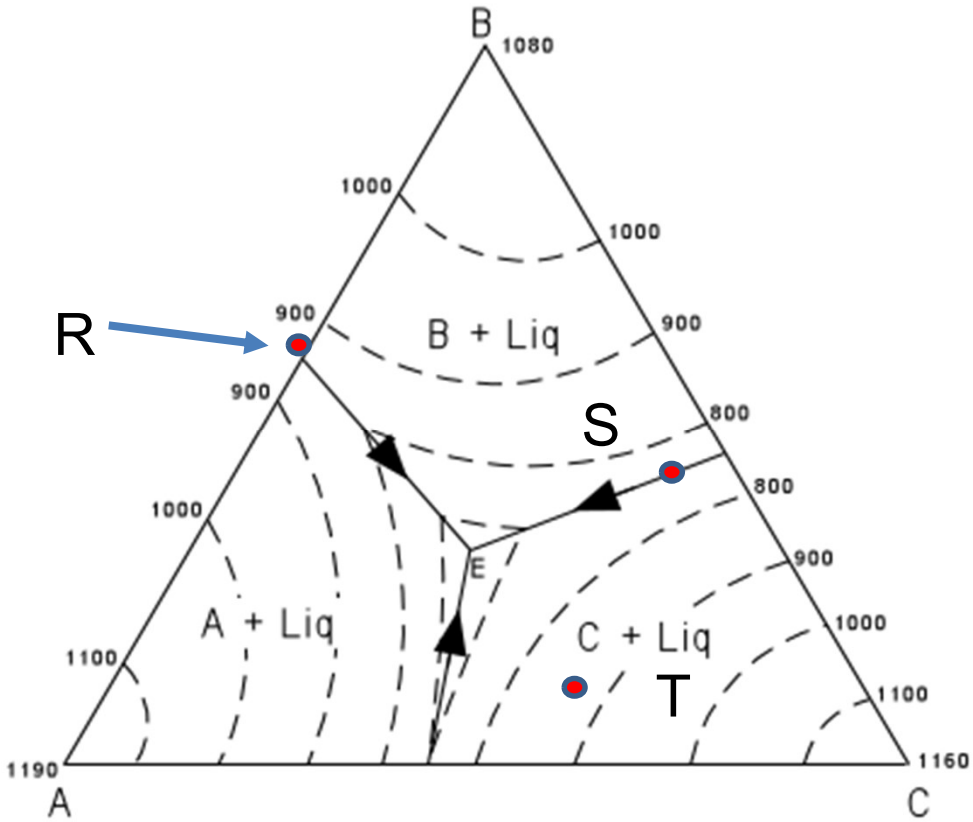


Figure 2

Question 5

Consider a mild steel gear with a composition of 0.25 wt.% carbon that is subjected to gas carburizing using methane gas at 980 ˚C. If the concentration of carbon at the surface is suddenly brought to and maintained at 1.20 wt.% carbon, how long will it take to achieve a carbon content of 0.80 wt.% at a position 0.5 mm below the surface? The diffusion coefficient for carbon in iron at this temperature is 1.6×10^{-11} m^2 s^{-1}.

Assume that the gear is semi-infinite.

Question 6

We have studied the process of solutioninzing and ageing to achieve optimum hardness in Al-4wt% Cu alloy commonly known as duralumin. The increase in strength is accompanied with decrease in corrosion resistance to the atmosphere. In order to improve the corrosion resistance 20 mm thick duralumin sheets are covered on either side with 0.2 mm thick pure aluminium sheets. For retaining the corrosion resistance, the copper concentration at a depth of 0.1 mm from the outer surface should not exceed 0.4 %. How long can the material be kept at 500 ^{o}C, without damaging the corrosion resistance if the diffusivity of copper in aluminium at 500 ^{o}C is

$$D_{Cu\ in\ Al} = 5 \times 10^{-13}\, m^2 s^{-1}$$

Error function

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999