DECEMBER 2012 NATIONAL EXAMINATIONS

04-BS-11 Properties of Materials

3 Hours Duration

Notes:

(i) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumption made.

(ii) Candidates may use one of two calculators, the Casio or Sharp approved models. This is a "closed book" examination.

(iii) Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.

(iv) All questions are of equal value.

Information:

(1) Atomic Masses ($g.mol^{-1}$)

H	1.0	C	12.0	N	14.0	O	16.0	Al	27.0	S	32.0
Cl	35.5	Cr	52.0	Sn	118.7	Pb	207.2				

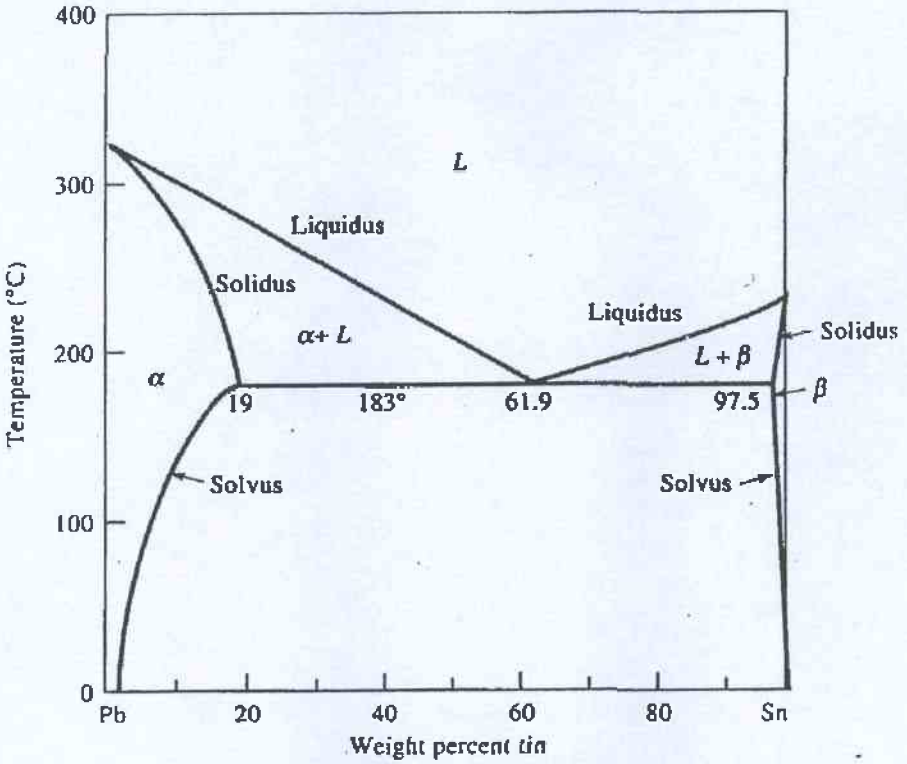
(2) Constants and Conversions

Avagadro's number, N_A $= 0.602 \times 10^{24}\ mol^{-1}$
Boltzmann's constant, k $= 13.8 \times 10^{-24}$ J/atom·K
Universal gas constant, R $= 8.314$ J/mol ·K

(3) Prefixes

tera	T	10^{12}	milli	m	10^{-3}
giga	G	10^{9}	micro	μ	10^{-6}
mega	M	10^{6}	nano	n	10^{-9}
kilo	k	10^{3}	pico	p	10^{-12}

Questions:



Lead - Tin Phase Diagram

1. (a) A 30% Sn alloy of lead-tin is slowly cooled from a temperature of 350°C. Determine the:

   (i) Composition of the first solid to form.
   (ii) The freezing range of the alloy.
   (iii) Amounts and compositions of each phase at 184°C.
   (iv) Amounts and compositions of each phase at 182°C.
   (v) Amounts and compositions of each phase at 25°C.

   (b) Repeat part (a) but for an 80% Sn alloy.

2. (a) Determine the ASTM grain size of a metal if 42 grains are counted in a circle of diameter 2 inches at a magnification ×200. Determine also the average grain diameter in mm (1 inch = 25.4 mm).

   (b) Show that the minimum ionic radii ratio for three fold coordination is 0.155. Explain why this is a minimum and not a maximum value.

   (c) What are the major factors that affect the creep rate of silicate glasses? Explain.

3. (a) PVC (polyvinyl chloride) is usually used as a copolymer with PE (polyethylene) rather than as a homopolymer. Why? The copolymer is normally syndiotactic. Would you expect the copolymer to be crystalline? Thermoplastic or thermosetting? Explain your answers.

(b) Name and describe the processing methods to make the following: polyethylene squeeze bottle, melamine dish, nylon fishing line, fibreglass boat hull.

(c) A rubber contains 92% by weight polymerized chloroprene ($CH_2CClCHCH_2$) and 8% sulphur. What fraction of the chloroprene is crosslinked? Assume that all the sulphur is utilized in the crosslinking.

4. Chromium has a body centered cubic structure and atomic radius 0.1249 nm. Calculate the density ($g.cm^{-3}$) of chromium. Sketch the unit cell. On your sketch show the (112) plane and [011] direction. What is the spacing (nm) between the (102) planes?

5. (a) Describe and illustrate edge and screw type dislocations.

(b) Discuss the role played by dislocations in the cold working and subsequent annealing of metals and alloys.

6. (a) Explain how you would obtain the following microstructures in a 0.45% plain carbon steel: ferrite and pearlite; all martensite; all spherodite; all bainite.

(b) Describe the Jominey test. What useful information does it provide?

(c) Gas porosity in castings can cause service failures. What are some of the common causes of this porosity? How can the castings be checked for porosity?

7. (a) Indicate, with reasons, whether the corrosion rate of a piece of iron placed in tap water is increased or decreased by doing the following:

(i) Adding NaCl to the water
(ii) Using a dry cell battery to impose electron flow *into* the iron
(iii) Placing nickel in contact with the iron
(iv) Adding chromate ion to the water
(v) Freezing the water

(b) Why are some stainless steels prone to corrosion after welding?

(c) In concentration cells corrosion occurs at the region having the lower concentration. Explain.