ORDRE DES INGÉNIEURS DU QUÉBEC

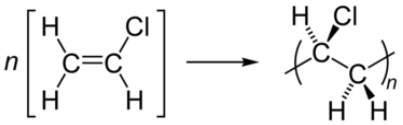
MAY 2015 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-CH-B3 SIMULATION, MODELING AND OPTIMIZATION

Polymers and plastics

1. Molecular weight of polymers (5 pts)



polyvinyl chloride

Figure 1

A sample of polyvinyl chloride (PVC) has been fractionized using a chromatography technique. The degree of polymerization of each fraction collected is shown in the following Table:

Molar fraction	Degree of Polymerization
0.10	200
0.20	300
0.40	400
0.15	600
0.10	800
0.05	1500

a) Calculate the weight average (*Mw*) and number average molecular weight (*Mn*) of this polymer, and the resulting polydispersity.

b) What amount (mass) of a monodispersed PVC of M= 1 000 000 g/mol should be blended with 10g of the polymer described in a) to obtain a PVC of Mw = 60 000 g/mol ?

2. Artwork suspension (5 pts)

You are being asked to select a nylon wire to suspend a 6.4 kg artwork. For aesthetical reasons, one would like this wire to be as thin as possible, while being able to limit the change in vertical position the object over time to less than 0.66% within one year. What should be de diameter of the wire, knowing that this material has the creeping behaviour reported in Figure 2 ?

A)

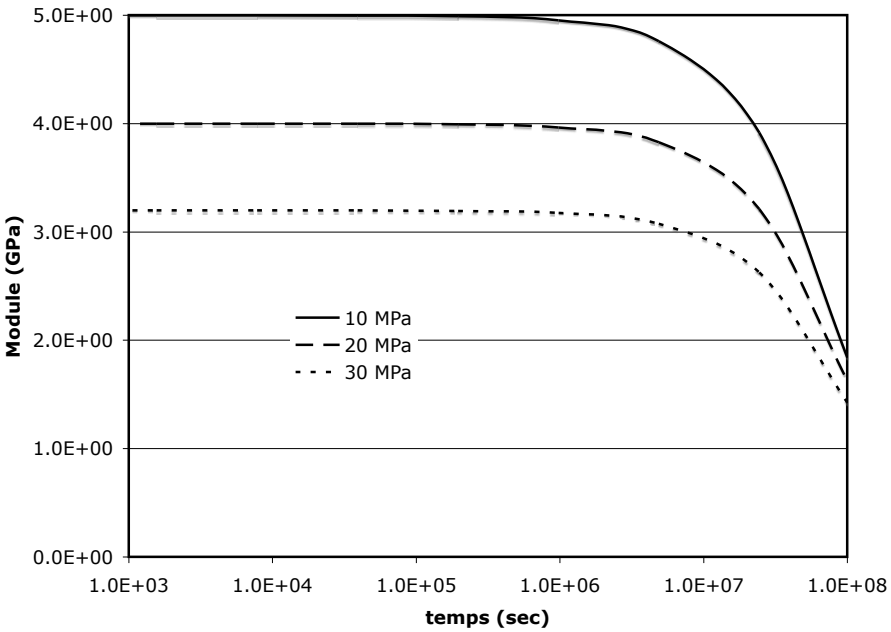


Figure 2

Composites materials

3. Design of a beam (10 pts)

As a newly hired engineer in a composite beam manufacturer, you are given the task of designing a beam satisfying the following criteria:

- Length: 1m
- Rectangular cross-section: 0.1m x 0.2 m
- Matrix: epoxy
- Fibers: long, continuous

The beam has to be able to withstand a traction load of 1 500 000 kg, while having a deformation of less that 9 mm. It is also desired to have this part as light as possible. To achieve this task you have access to the following materials:

Material	Density (kg/m^3)	Tension Modulus (GPa)	ε maximum (%)	Fibers diameter (□m)
MATRIX				
Epoxy	1200	6	2.4	N/A
FIBERS				
E-glass	2540	76	2.8	12
Carbone	1790	230	1.1	12
Bore	2650	420	0.7	14

Metal and Alloys

4. Hardening of metallic alloys : (5 pts)

For each of the alloys shown in the following Table, mark with an X the relevant hardening mechanism(s).

	Mechanism		
Alloy or metal	Solution hardening	Precipitation	Work hardening
Pur Al or Cu			
Low-carbon steel			
Nickel alloys			
Stainless steel			
Aluminum alloys without thermal treatment			

5. Binary phases diagram : (5 pts)

Use the Pb-Sn Phases Diagram shown in Figure 3 to answer the following questions:

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a) The composition locus for a 25% Pb alloy at 250 °C is found in a two-phases region of the diagram. Draw a corresponding tie-line on the Figure to obtain the compositions and respective proportion of the two phases.

b) This alloy is slowly cooled down. Identify the respective phases and compositions at (i) 200 °C and (ii) 150 °C.

c) Use arrows to sketch the evolution of the phases compositions during the cooling process from 250 °C to 200 °C. The overall composition remains constant. How is this possible ?

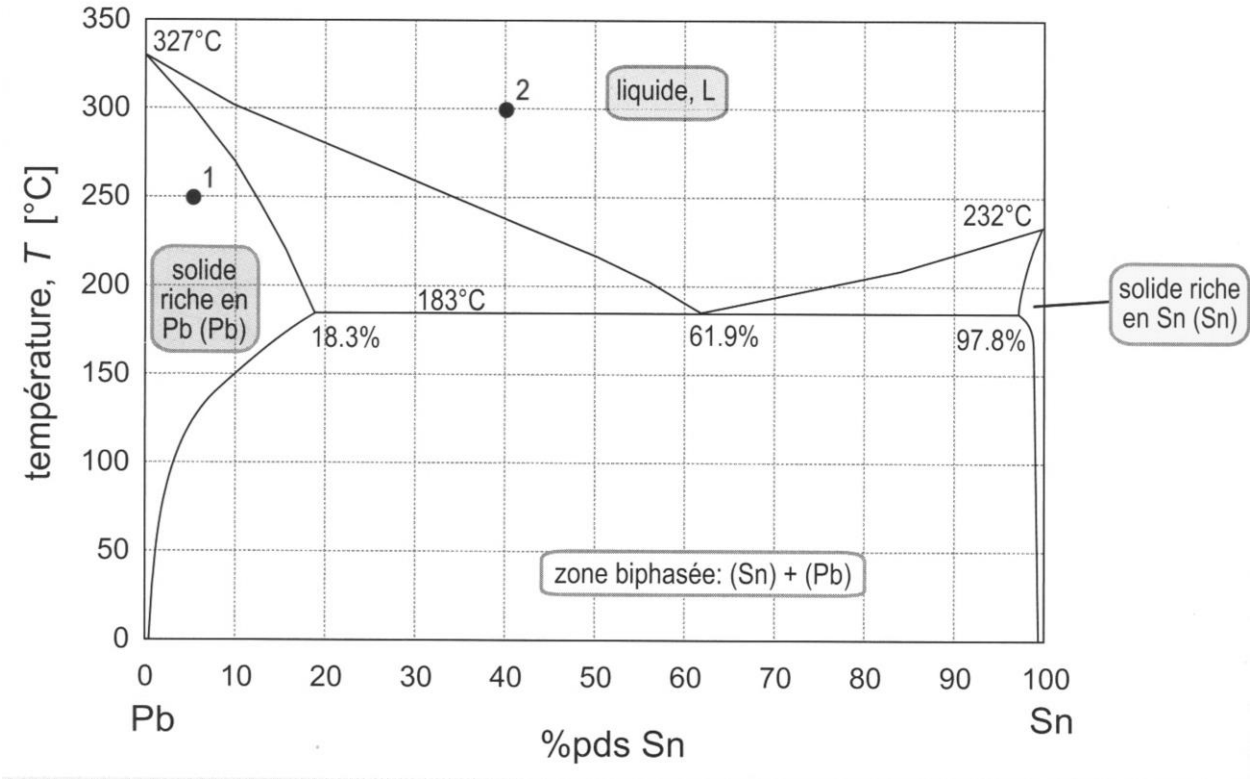

Figure 3 Pb-Sn Phases Diagram

Ceramics

6. Answer by False or True (10 pts)

a) Acidic refractory materials are often blends of silica and corundum. _____

b) Dolomite is an alkaline refractory material. _____

c) Glasses are crystalline solids. _____

d) Magnesia is the main constituent of clay. _____

e) The sintering is a process by which ceramics is transformed into dust._____

f) Earthenware are generally less porous than stoneware._____

g) The disruptive tension of a ceramic generally decreases when its temperature increases. _____

h) Compression strength of an acidic refractory material decreases when its alumina content increases. _____

i) Graphite has both covalent and Van der Waals bonds. _____