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Faculté de génie

Département de
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CHG 4305
Advanced Materials in Chemical Engineering
2015
To be finished in 75 min

Date : November 6th, 2015, 13:00 hrs Professor: André Y. Tremblay

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Note:

1) Closed book + **1 sheet of 8.5 x 11 letter sized paper, single sided.**
2) Work on this booklet and the standard examination booklet. **SUBMIT BOTH BOOKLETS**
3) There are a total of 6 questions.
4) Place a box around your answer.
5) Hand in all sheets - do not detach papers from the staple.
6) Non programmable calculators only; such as TI 30X

QUESTION	1)	7 / 10 marks	+1
	2)	~~4~~ / 6	
	3)	5 / 5	
	4)	7 / 7	
	5)	7 / 7	
	6)	15 / 15	
	TOTAL	45 / 50	

Question 1: (10 marks)

1.1 (2) Name two types of solid solutions:

-2

Glassy

Rubbery

1.2 (2) Name two conditions for the optimal design of a zone refining process.

Strong Convection in melt and high diffusion rate of solute in melt.

Low pulling rate of molten zone and short zone length

1.3 (2) Circle the correct answer

a) The Tg of rubbery polymers is greater or (less) than ambient temperature?

b) The addition of side chains onto the main chain of a polymer causes a

decrease or increase in the value of Tg?

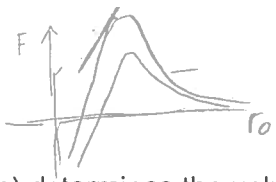
-1

1.4 (2) Resilient materials have the two following characteristics:

a) Have high yield strength (σ_y)

AND

b) Low moduli of Elasticity (E)



1.5 (2) At the atomic level: What differential (slope) determines the value of Young's modulus?

$E \propto \left(\frac{dF}{dr}\right)_{r_o}$ where E is affected by bond strength. Higher the bond strength, higher the E. Also we can find through secant (slope) and linear interpolation.

2) (6) A silicon bar is zone refined to remove trace impurities. The bar is held vertically. The base of the bar is supported. A heated zone surrounding the bar is passed from the lower end of the bar to the upper end. The bar is 80 cm long and its diameter is 10 cm. The heating zone travels at a speed of 2 cm/h. The initial concentration of an impurity in the silicone bar is 12 ppm. In order to purify the silicon, the heated zone is passed 15 times from the lower end to the upper end of the bar.

After the zone refining process, the concentration at the lower tip of the bar (very lowest point on the bar) is 1.5 ppm while the concentration ¼ (one quarter) up from the bottom of the bar is 4 ppm.

Determine the length of the heated zone used in the refining process.

3) (5) The modulus of elasticity for alumina (Al_2O_3) having 4 vol% porosity is 300 GPa.

Compute the modulus of elasticity for the nonporous material.

4) (7) A cylindrical specimen of some alloy 7 mm in diameter is stressed elastically in tension. A force of 14,900 N produces a reduction in specimen diameter of 6×10^{-3} mm. Compute Poisson's ratio for this material if its modulus of elasticity is 140 GPa.

$$E_0 = \frac{300}{(1 - 1.9(0.04) + 0.9(0.04)^2}$$

5) (7) The following true stresses produce the corresponding true plastic strains for a brass alloy:

True Stress (MPa)	True Strain
344	0.10
414	0.20

What true stress is necessary to produce a true plastic strain of 0.26?

6) (15) A silicon wafer was doped with arsenic using both predeposition and drive-in heat treatments; the background concentration of A in the silicon material was 6×10^{12} atoms/m^3. The predeposition diffusion was carried out at 950°C for 4 hours. The drive-in diffusion treatment was carried out at 1150°C for a period of 12.0 hours. The observed junction depth for drive-in diffusion was 2.9 micrometers.

Determine the surface concentration of A during the predeposition step.

For the diffusion of A in Si, values of Q_d and D_0 are 4.6 eV/atom and 0.352 m^2/s, respectively.

Show all calculations and place a box around your answer.

$k = 8.62 \times 10^{-5}$ eV/atom-K

Values of *R*	**Units ($V P T^{-1} n^{-1}$)**
8.31	$J K^{-1} mol^{-1}$
5.189×10^{19}	$eV K^{-1} mol^{-1}$
0.082	$L atm K^{-1} mol^{-1}$
1.987	$cal K^{-1} mol^{-1}$
1.987×10^{-3}	$kcal K^{-1} mol^{-1}$
8.31×10^{7}	$erg K^{-1} mol^{-1}$
8.31	$L kPa K^{-1} mol^{-1}$
8.31	$m^3 Pa K^{-1} mol^{-1}$
8.31×10^{-5}	$m^3 bar K^{-1} mol^{-1}$
8.20×10^{-5}	$m^3 atm K^{-1} mol^{-1}$