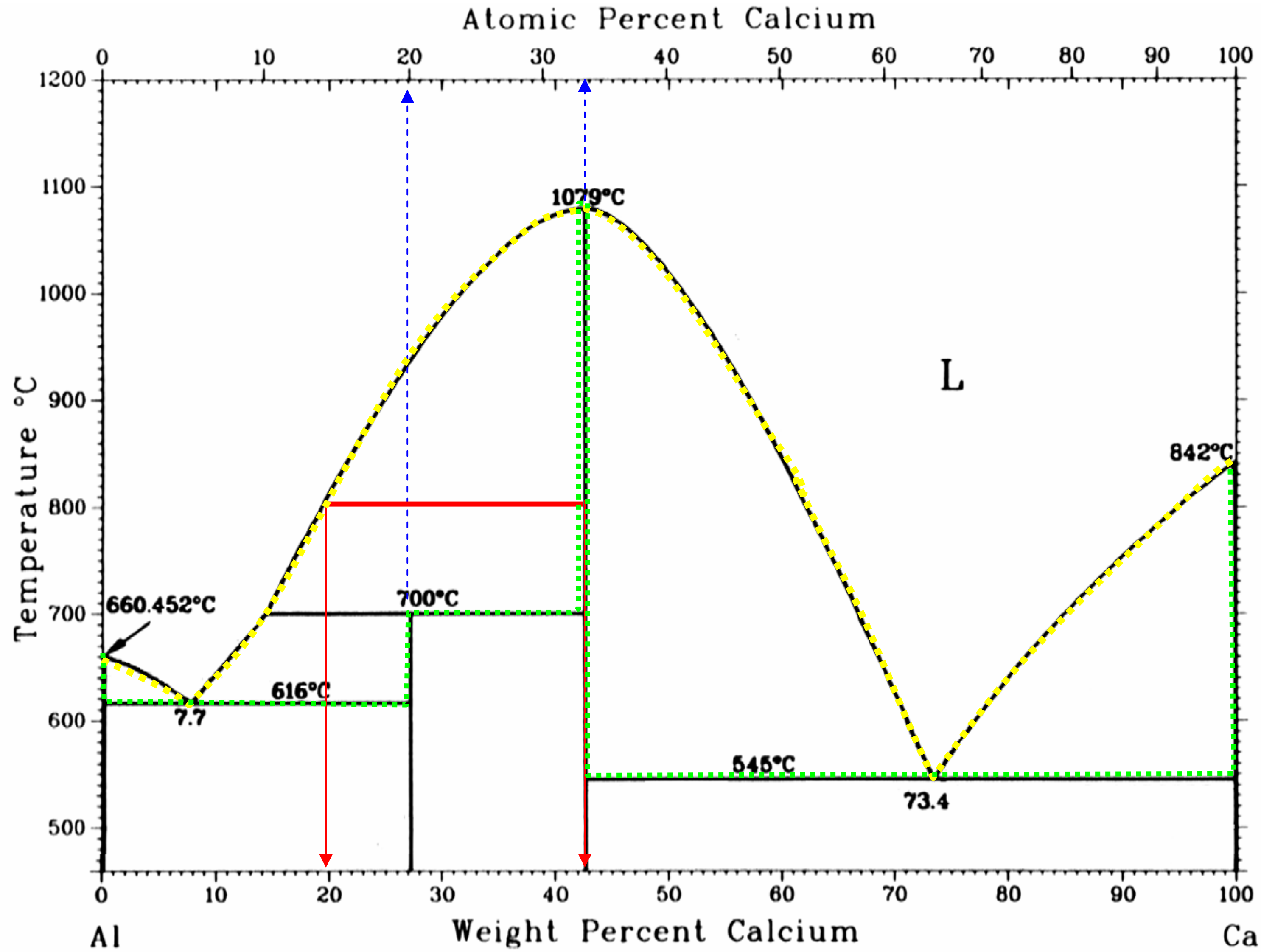
INGE 4001 – Sections 076
Instructor: O. M. Suárez – Graduate Assistants: Hermes Calderón
Phase Diagram Last Quiz – Tuesday May 2, S-303
Maximum grade: 15 points - Maximum time: ½ hour

Name Student Number:

Aluminum-calcium alloys are being used in the production of metallic foams for heat dissipation and shock absorbing mechanisms. For the following Al-Ca equilibrium phase diagram respond to the following requests:

a) Indicate the liquidus, solidus and -if any- solvus lines
b) Identify (indicate which type) and label ALL invariant (isothermal) transformations in the diagram
c) Identify all intermediate phases present and provide their chemical formula.
d) For the alloy containing 27.3 wt.% Ca – 72.7 wt.% Al (exactly on that vertical line) calculate the relative amounts of phases present and their chemical compositions at 800ºC and at 616ºC.



a) Indicated in the graph: liquidus solidus There is no visible solvus line.
b) Three horizontal lines in the graph are isothermal transformations.
Peritectic at 700ºC Al_2Ca + Liq. ↔ Al_4Ca

Continue your work on the back of the paper

Eutectic at 616ºC Liq. ↔ Al_4Ca +Al
Eutectic at 545ºC Liq. ↔ Al_2Ca +Ca

c) There are two intermediate phases (line compounds) at 27.3wt.% Ca (20 at.% Ca) and at 42.7 wt.% Ca (33.33 at.% Ca). Their corresponding chemical formulae are: Al_4Ca (20 at.% Ca, 1/5 moles are Ca) and Al_2Ca (⅓ moles are Ca).

d) For the alloy containing 27.3 wt.% Ca – 72.7 wt.% Al
at 800ºC:

Chemical composition: Liq.: 19.5 wt.% Ca, 81.1 wt.% Al
Al_2Ca: 42.7 wt.% Ca, 57.3 wt.% Al

Relative amount of phases:

$$\text{Liq.\%} = \frac{42.7\text{-}27.3}{42.7\text{-}19.5} \cdot 100 = 66.4\%$$

$$Al_2Ca\text{:\%} = \frac{27.3\text{-}19.5}{42.7\text{-}19.5} \cdot 100 = 33.6\%$$

at 616ºC.

Chemical composition: Al_4Ca.: 27.3 wt.% Ca – 72.7 wt.% Al

Relative amount of phases: Al_4Ca:% = 100 % (everything is Al_4Ca on that vertical line)

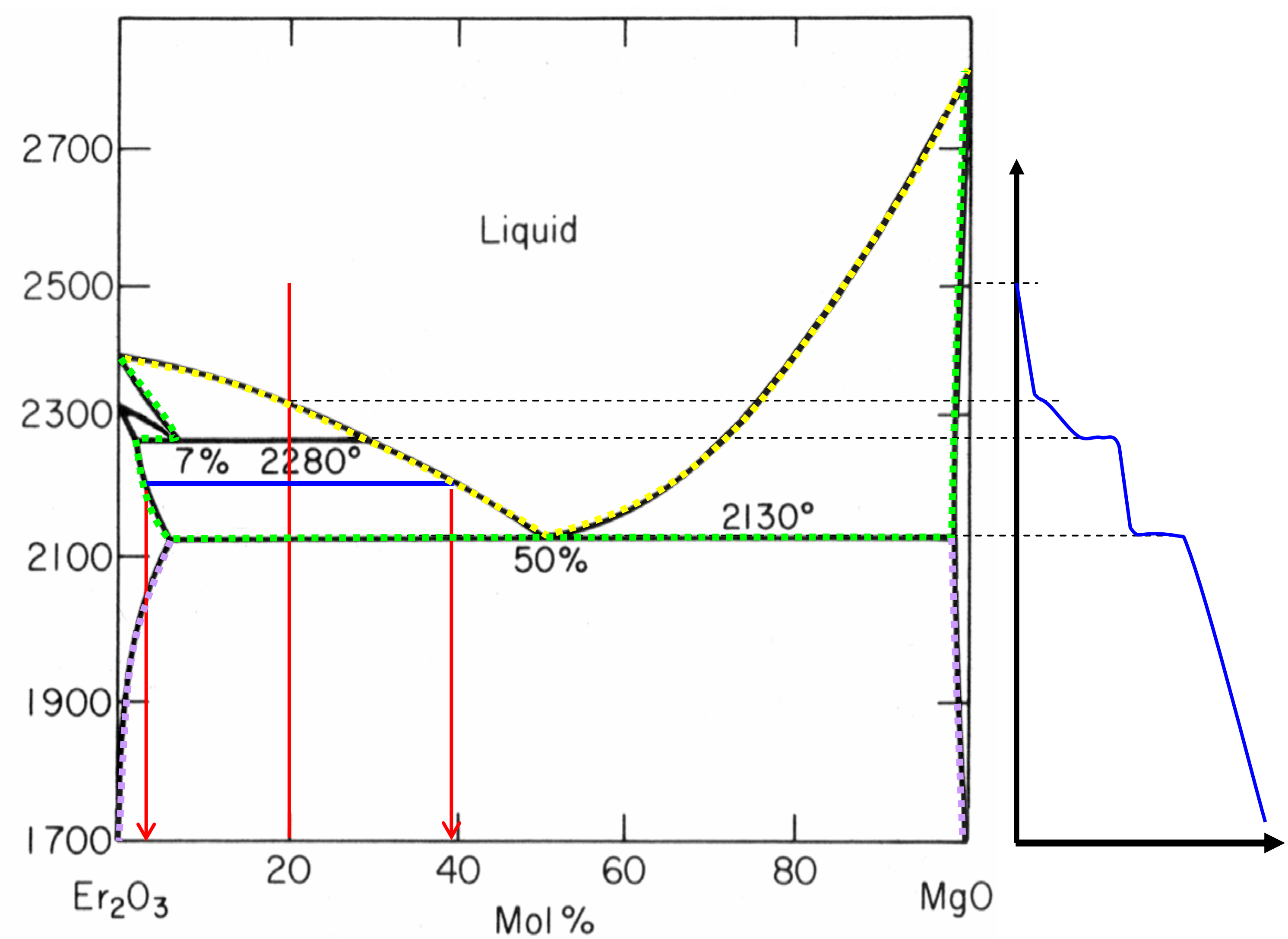
Continue your work on the back of the paper

INGE 4001 – Sections 066
Instructor: O. M. Suárez – Graduate Assistants: Hermes Calderón
Phase Diagram Last Quiz – Tuesday May 2, S-303
Maximum grade: 15 points - Maximum time: ½ hour

Name   Student Number:

Magnesia-doped erbia is being used in multilayered capacitors for their high dielectric constant. For the following Er_2O_3-MgO equilibrium phase diagram respond to the following requests:

a) Indicate the liquidus, solidus and -if any- solvus lines
b) Is erbia or magnesia polymorphic? Justify your answer.
c) Identify (indicate which type) and label ALL invariant (isothermal) transformations in the diagram
d) For the ceramic containing 20 mol.% MgO –80 mol.% Er_2O_3 calculate the relative amounts of phases present and their chemical compositions at 2200ºC. Then sketch the cooling curve for this composition starting at 2500ºC (you should do this at the proper temperature scale)



a) Indicated in the graph: liquidus ...... solidus ...... solvus ......
b) Erbia is polymorphic: at 2310ºC it goes from one crystal structure α to another one β (upon cooling).
c) Two horizontal lines in the graph are isothermal transformations.
Metatectic at 2280ºC $\alpha. \leftrightarrow \beta$ + Liq.

Continue your work on the back of the paper

Eutectic at 2130ºC Liq. ↔ β+ γ

d) There are two intermediate phases (line compounds) at 27.3wt.% Ca (20 at.% Ca) and at 42.7 wt.% Ca (33.33 at.% Ca). Their corresponding chemical formulae are: Al_4Ca (20 at.% Ca, 1/5 moles are Ca) and Al_2Ca (⅓ moles are Ca).

d) For the ceramic containing 20 mol.% MgO –80 mol.% Er_2O_3
at 2200ºC:

Chemical composition: Liq.: 3 mol.% MgO, 97 mol.% Er_2O_3
β: 39 mol.% MgO, 61 mol.% Er_2O_3

Relative amount of phases: $\text{Liq.\%} = \frac{20-3}{39-3} \cdot 100 = 47.2\%$

$\beta\ \% = \frac{39-20}{39-3} \cdot 100 = 52.8\%$

The cooling curve is indicated by the phase diagram. For each crossing of an isothermal transformation there is a flat segment (isothermal).

Continue your work on the back of the paper

INGE 4001-Section 066

Instructor: O. Marcelo Suárez

Grad Student Assist.: Hermes Calderón

Phase Diagrams - Quiz #3 - 15 Points -Maximum time: 25 minutes

Name: Student Number:

Solid-state batteries constructed from indium sulfides (In_2S_3) can be doped with lead for the production of more efficient batteries. For the following In_2S_3-Pb equilibrium phase diagram answer the following questions:

a) Are In_2S_3 and/or Pb polymorphic? In_2S_3 is polymorphic but not lead.

b) Indicate the liquidus, solidus and -if any- solvus lines

c) Identify (indicate which type) and label ALL invariant transformations in the diagram } 2 Metatectics, 1 eutectic

d) Identify all intermediate phases (or compounds) present. There is no intermediate phase

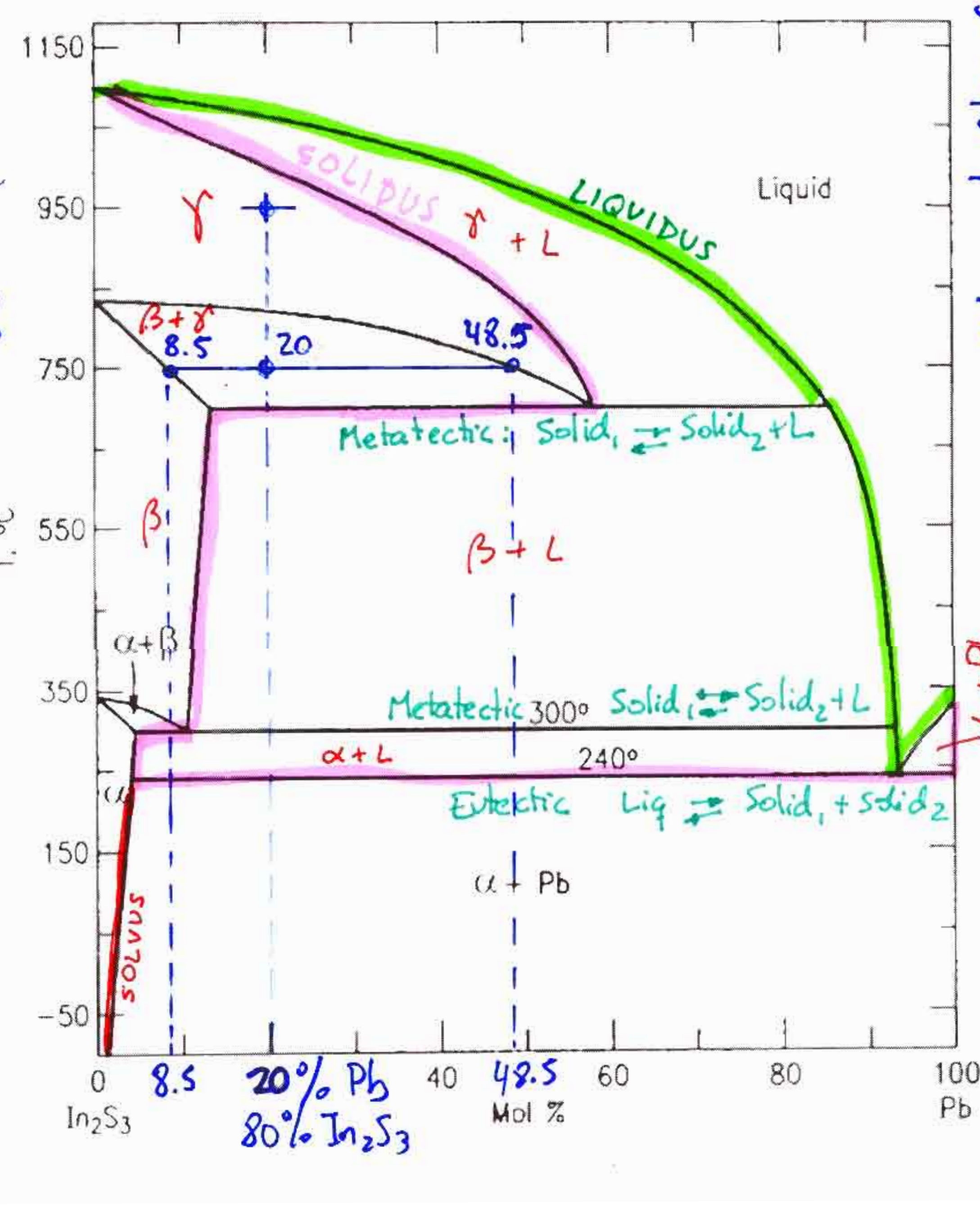
e) Label ALL regions in the phase diagram with the corresponding phases present (some tips were provided)

f) For the composition 20 mol% Pb – 80 mol% In_2S_3 calculate the relative amounts of phases present and their chemical compositions at the following temperatures: 750°C and 950°C.

f) @750° two phases present: γ & β

Chem. Comp. γ { 48.5% Pb, 51.5% In_2S_3 ; β { 8.5% Pb, 91.5% In_2S_3

Rel. amount. $\% \gamma = \left(\frac{20-8.5}{48.5-8.5}\right)100 = 19.8\%$; $\% \beta = \left(\frac{48.5-20}{48.5-8.5}\right)100 = 80.2\%$



f) @950°C There's only one phase: γ

Rel amount 100% γ

Chem. Comp. γ { 20% Pb, 80% In_2S_3

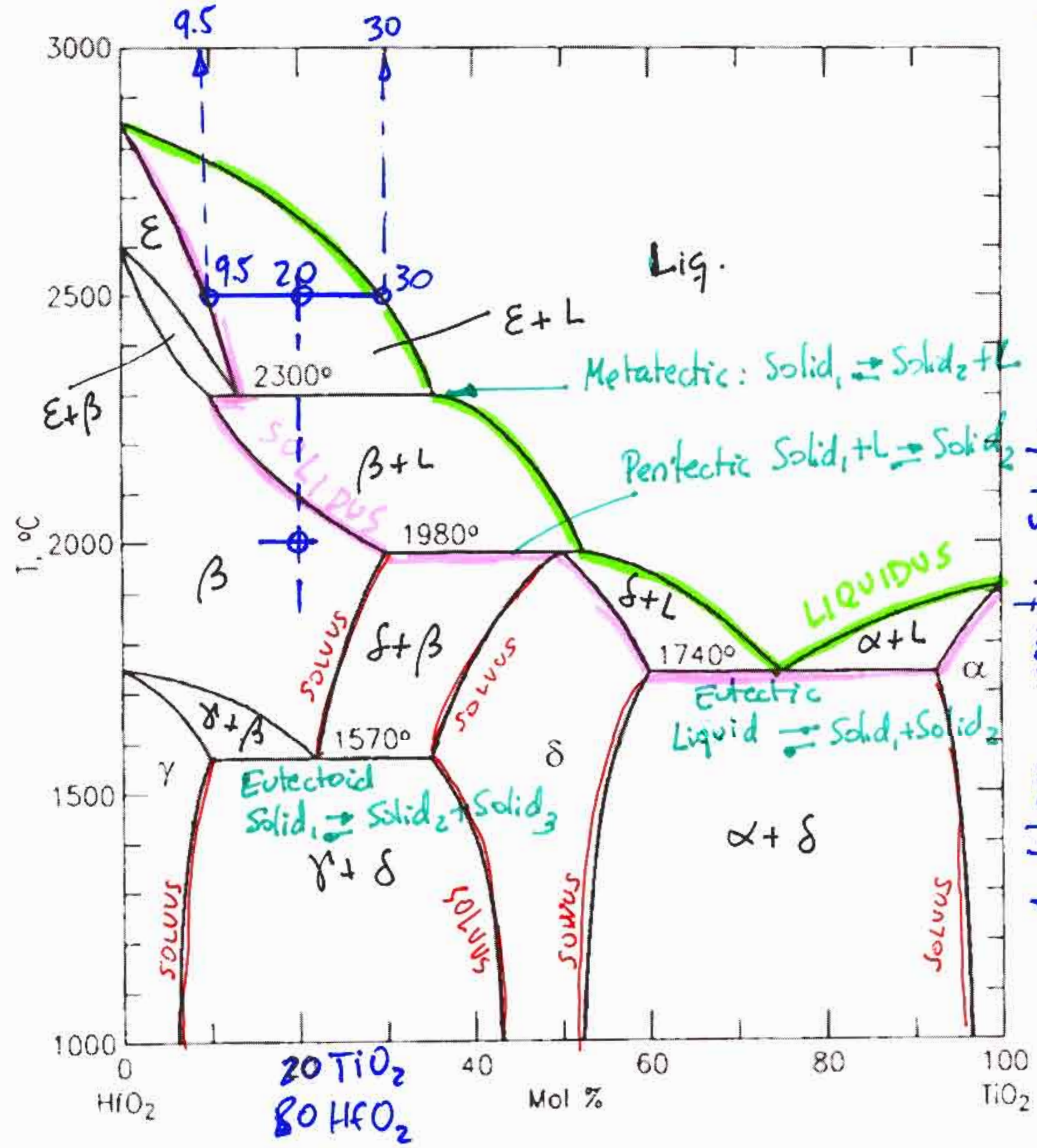
INGE 4001-Section 076
Instructor: O. Marcelo Suárez
Grad Student Assist.: Hermes Calderón
Phase Diagrams - Quiz #3 - 15 Points -Maximum time: 25 minutes

Name: Student Number:

Compounds of hafnia (HfO_2) and rutile or titania (TiO_2) are being used in capacitors for their high κ (dielectric constant). For the following HfO_2 - TiO_2 equilibrium phase diagram respond to the following requests:

g) Are HfO_2 and/or TiO_2 polymorphic? Only hafnia is polymorphic
h) Indicate the liquidus, solidus and -if any- solvus lines
i) Identify (indicate which type) and label ALL invariant transformations in the diagram. { Metatectic, Eutectoid, Peritectic, Eutectic
j) Identify all intermediate phases (or compounds) present. Only one: δ
k) Label ALL regions in the phase diagram with the corresponding phases present (some tips were provided)
l) For the composition with 20 mol % TiO_2 – 80 mol% HfO_2 calculate the relative amounts of phases present and their chemical compositions at the following temperatures: 2000°C and 2500°C.

f) @ 2000°C there's only one phase β therefore: Rel. amount: 100% β with chem. comp. { 20% TiO_2, 80% HfO_2



f) @ 2500°C two phases present: ε + L

Chem. Comp: ε { 9.5% TiO_2, 81.5% HfO_2

L { 30% TiO_2, 70% HfO_2

Rel. amount $\%\varepsilon = \frac{30-20}{30-9.5} 100 = 48.7\%$

$\%L = \frac{20-9.5}{30-9.5} 100 = 51.3\%$

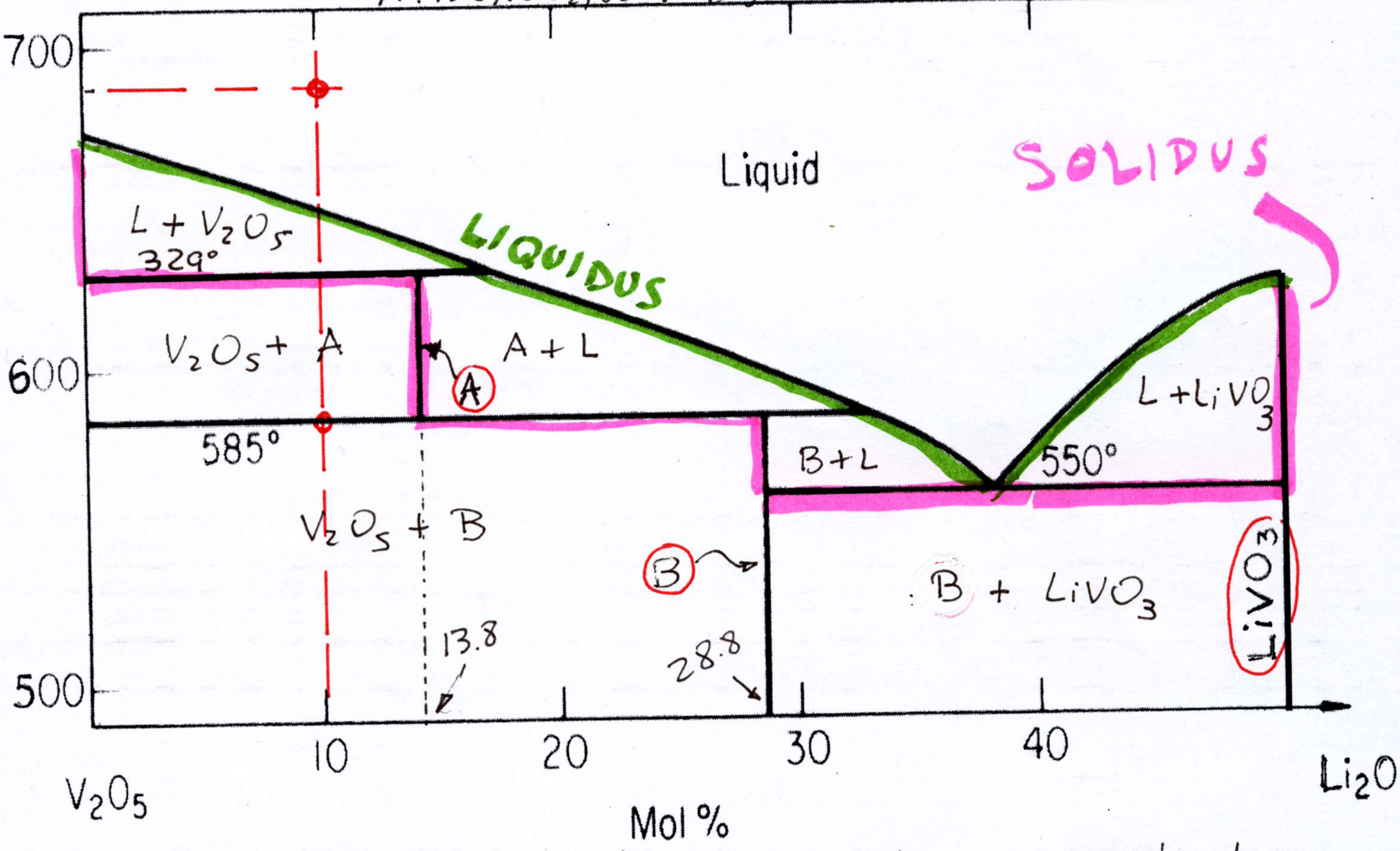
INGE 4001-Section 016
Instructor: O. Marcelo Suárez
Grad Student Assist.: Hermes Calderón
Phase Diagrams - Quiz #3 - 12 Points -Maximum time: 20 minutes

Name: Student Number:

Vanadia (V_2O_5) and lithia (Li_2O) are used in the production of advanced glasses. The following is a **partial** V_2O_5-Li_2O equilibrium phase diagram (limited to 50 mol% Li_2O where the $LiVO_3$ line compound is located. Please respond to the following requests:

a) Indicate the liquidus, solidus and -if any- solvus lines
b) Identify (indicate which type) and label ALL invariant transformations in the diagram
c) Identify all intermediate phases (or compounds) present.
d) Label ALL regions in the phase diagram with the corresponding phases present.
e) For the composition 10 mol% Li_2O – 90 mol% V_2O_5 calculate the relative amounts of phases present and their chemical compositions at the following temperatures: 690°C and 585°C.

e) @ 585+Δ: V_2O_5: 100% V_2O_5
A: 13.8% LiO_2, 86.2% V_2O_5
$\%V_2O_5 = \frac{13.8-10}{13.8-0} 100 = 27.5\%$ $\%LiO_2 = 72.5\%$



a) Liquidus (green) Solidus (pink) There are no soluus lines

b) There are 3 isothermal transformations:
@ 329°C: $L + V_2O_5 \rightleftharpoons A$ peritectic
@ 585°C: $A \rightleftharpoons V_2O_5 + B$ eutectoid
@ 550°C: $L \rightleftharpoons B + LiVO_3$ eutectic

c) There are 3 intermediate phases: A, B and $LiVO_3$

e) @ 690°C: 100% Liq
Liq: 10% Li_2O, 90% V_2O_5

@ 585°C−Δ
V_2O_5: 100% V_2O_5
B { 28.8% LiO_2, 71.2% V_2O_5
$\%V_2O_5 = \frac{28.8-10}{28.8-0} 100 = 65.3\%$
$\%LiO_2 = 34.7\%$

INGE 4001-Section 036
Instructor: O. Marcelo Suárez
Grad Student Assist.: Hermes Calderón
Phase Diagrams - Quiz #3 - 12 Points -Maximum time: 20 minutes

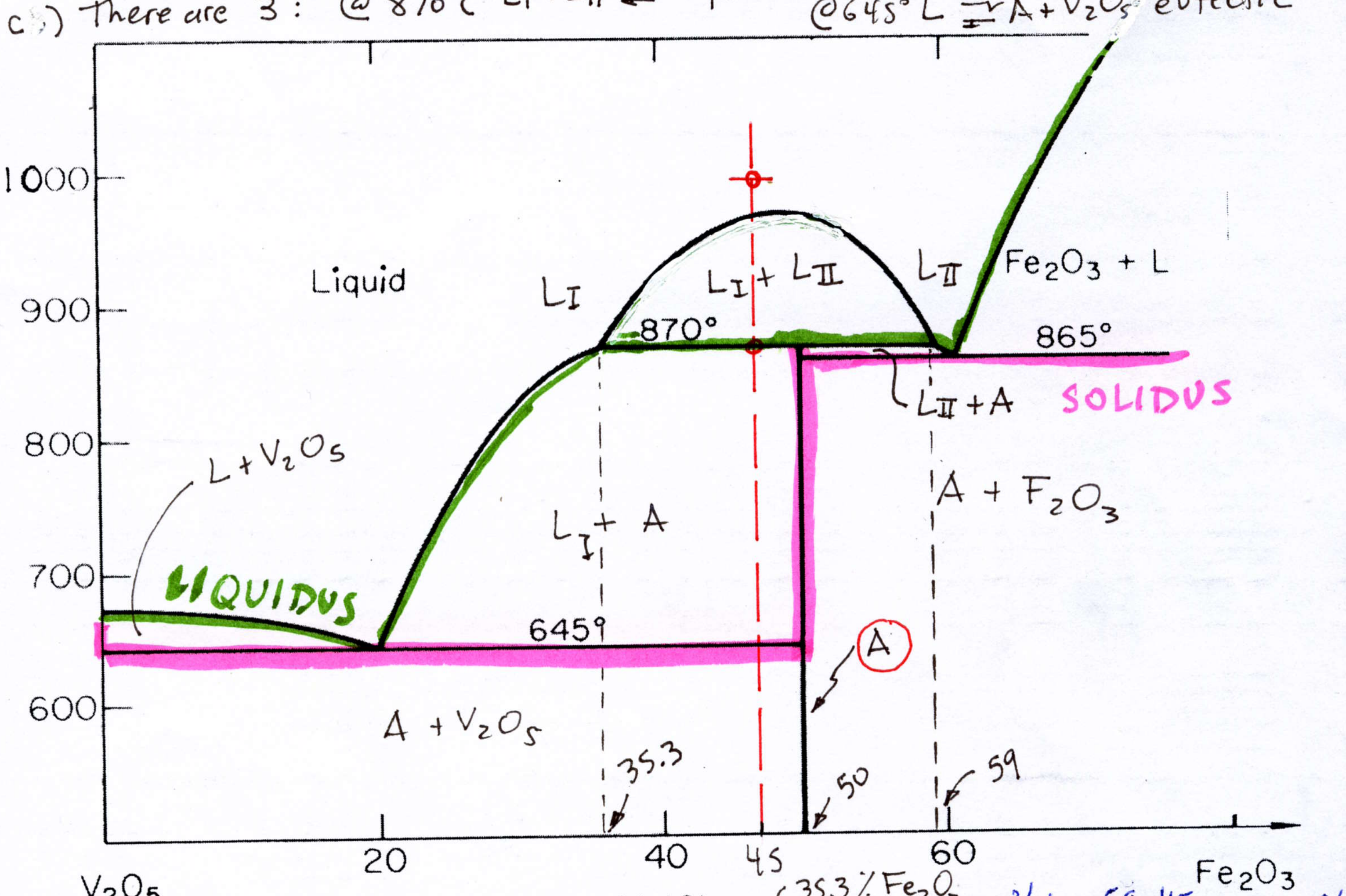
Name: Student Number:

Vanadia (V_2O_5) and hematite (αFe_2O_3) are being used in ceramic glazes. The following is a **partial** V_2O_5 - Fe_2O_3 equilibrium phase diagram limited to ~ 80 mol% Fe_2O_3. Please respond to the following requests:

a) Is there any intermediate compound? If there is one, does it melt congruently or not?
b) Indicate the liquidus, solidus and -if any- solvus lines
c) Identify (indicate which type) and label ALL invariant transformations in the diagram
d) Label ALL regions in the phase diagram with the corresponding phases present (some tips were provided)
e) For the composition with 45 mol % Fe_2O_3 – 55 mol% V_2O_5 calculate the relative amounts of phases present and their chemical compositions at the following temperatures: 870°C and 1000°C.

a) Yes (A) melts congruently.

c) There are 3: @ 870°C $L_I + L_{II} \rightleftharpoons$ Syntectic
@ 865° $L_{II} \rightleftharpoons A + F_2O_3$ eutectic
@ 645° $L \rightleftharpoons A + V_2O_5$ eutectic



e) @ 1000°C 100% Liq
L {45% Fe_3O_2, 55% V_2O_5}

@ 870°C + Δ: L_I {35.3% Fe_2O_3, 64.7% V_2O_5}
L_{II} {59% Fe_2O_3, 41% V_2O_5}

$\% L_I = \frac{59-45}{59-35.3} \times 100 = 59\%$

$\% L_{II} = 41\%$

@ 870°C − Δ: L_I {35.3% Fe_2O_3, 64.7% V_2O_5}
A {50% Fe_2O_3, 50% V_2O_5}

$\% L_1 = \frac{50-45}{50-35.3} 100 = 34\%$

$\% A = 66\%$