Name______________________________________

EPS 303 - Igneous homework #1

Part I. You receive a package in the mail from one of your colleagues who has just collected a suite of volcanic rocks that she wants to have chemically analyzed. However, in order not to bias the results, she won't tell you where the samples are from. So, you crush and analyze the rocks and come up with the compositions listed in the attached table. Your assistant calculates the CIPW norms for 5 of the rocks, but forgets to finish the job and leaves one blank.

(a) Give each of the six analyses a general rock name, e.g., basalt, andesite, dacite, rhyolite:

1: dacite These names are based just on SiO_2 content

2: basalt

3: basalt

4: rhyolite

5: andesite

6: basalt

(b) Look at the chemical analysis of sample 6; is this rock likely to have **nepheline** in the norm? What about **quartz** and/or **olivine**? What oxides in the analysis give you clues about each normative mineral? Note: you do **not** need to do a norm calculation to answer this question!

ne: Probably not – low Na2O, moderate SiO2 (compare to analyses 2 & 3)

qz: No – not enough SiO2

ol: Yes – high MgO and moderate SiO2

(c) Based on the normative analyses, give each basalt from part (a) a more explicit name, e.g., tholeiite, olivine tholeiite, or alkali basalt. Also, give a likely tectonic setting for each.

rock #:	name:	tectonic setting:
2	quartz tholeiite	mid-ocean ridge; continental flood basalt (plume)
3	alkali basalt	continental rift or hot spot
6	olivine tholeiite	mid-ocean ridge

Part II. The binary phase diagram for the system $\mathbf{KAlSiO_4\text{-}SiO_2}$ (attached) is shown for a constant pressure of 1 bar.

(a) List all of the components in this system: 2 components: $KAlSiO_4$ and SiO_2

(b) List all of the phases in this system: 6 possible phases: L Ks Lc Sa Cr Tr

(c) Label the eutectic(s), peritectic(s), solidus, and liquidus on the phase diagram. See diagram

(d) Track the equilibrium crystallization history of a melt with a composition of **40 wt% SiO_2** by determining the assemblage present and estimating abundances (relative percent) of each phase for each of the following temperatures. Calculate the thermodynamic variance at each temperature.

Temp., °C	Liquid	Ks	Lc	Sa	Cr	Tr	variance
1700	100						2
1600	100						2
1500	~75		~25				1
1400	~60		~40				1
1300	~50		~50				1
1200	~40		~60				1
1100			~20	~80			1
1000			~20	~80			1
900			~20	~80			1

(e) Describe the behavior of the melt when it reaches a temperature of 1150°C. Write out the chemical reaction that occurs at this temperature and state which phase is consumed.

1150° is the **peritectic** temperature: the system is **invariant** and must remain at constant temperatures until one phase is completely consumed. The reaction that occurs is **Lc + L = Sa**, and the phase that is consumed is **liquid**.

Part III. **(a)** The same melt as in Part IIa cools to a temperature of 1300°C, at which point the melt separates from the already-formed leucite crystals, rises into the crust, and undergoes final crystallization. Track the crystallization history of this melt in terms of the phase abundances at each of the following temperatures, and calculate the thermodynamic variance at each T.

Temp., °C	L	Ks	Lc	Sa	Cr	Tr	variance
1200	~90		~10				1
1100	~60			~40			1
990	45 to 0			55 to 80		0 to 20	0
900				~80		~20	1

(b) Describe the behavior of this melt when it reaches a temperature of 1150°C. Write out the chemical reaction that occurs at this temperature and state which phase is consumed.

Peritectic: the system is invariant and remains at constant T until a phase is consumed. Again, the reaction is L + Lc = Sa, but in this case **leucite** is the phase that is consumed.

(c) How did the fractionation history affect the silica content of the final rock relative to the rock in Part II?

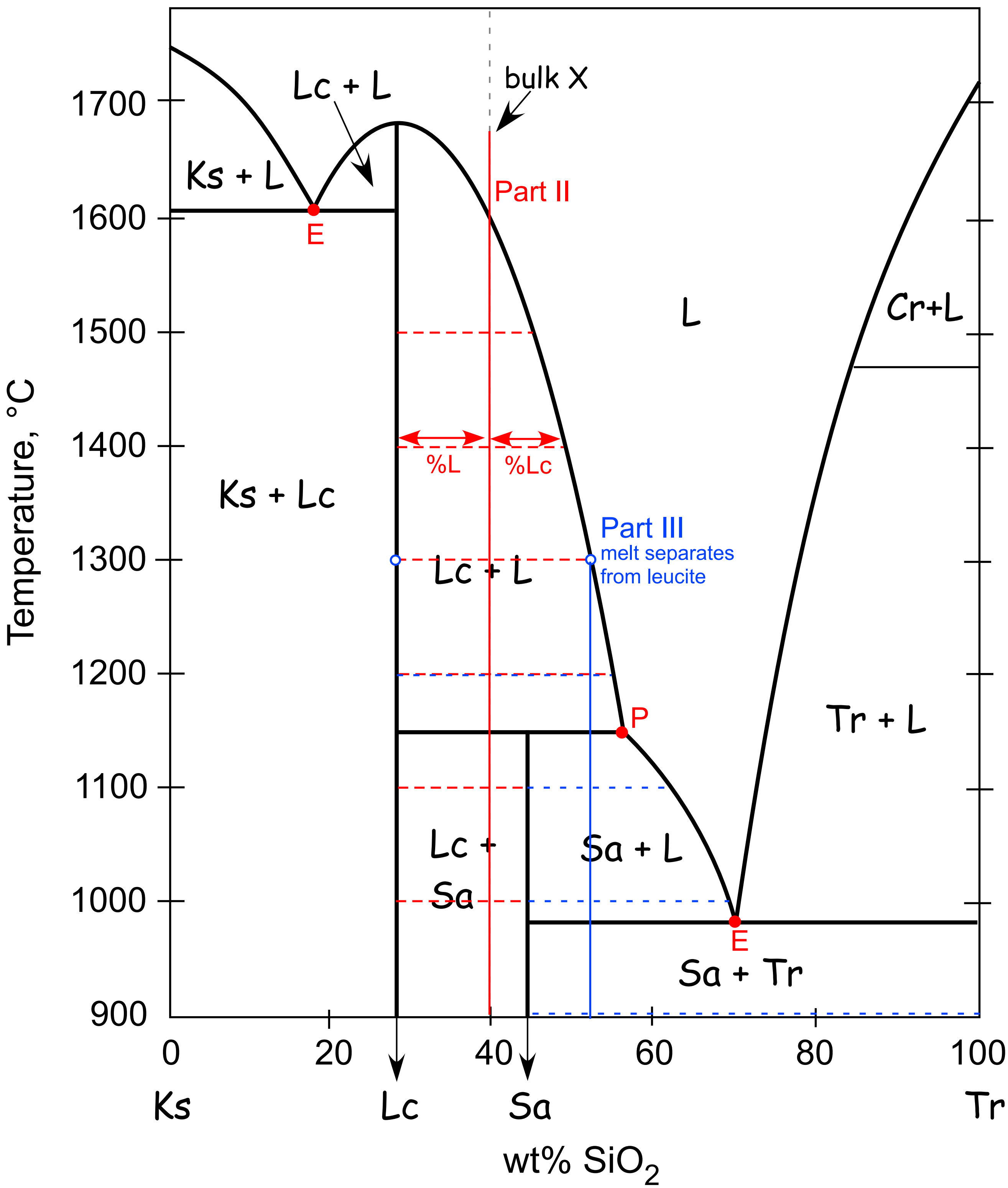
Early removal of Lc results in a final rock that is **more silica-rich** than the rock in Part II.

Name____

Rock analyses for Part I.

	1	2	3	4	5	6
SiO_2	67.73	50.83	46.66	76.21	58.57	47.01
TiO_2	0.50	3.44	2.44	0.07	0.64	3.20
Al_2O_3	15.44	12.67	16.01	12.58	19.87	15.57
Fe_2O_3	0.69	3.10	3.52	0.30	3.20	2.32
FeO	2.40	11.39	8.35	0.73	2.73	11.57
MnO	0.06	0.25	0.20	0.04	0.15	0.20
MgO	1.30	4.19	4.76	0.03	1.74	5.25
CaO	3.35	8.18	8.96	0.61	7.51	9.77
Na_2O	3.85	3.24	4.56	4.05	4.25	3.00
K_2O	3.25	0.87	1.86	4.72	0.74	0.31
P_2O_5	0.15	0.75	0.74	0.01	0.10	0.32
LOI*	1.15	0.94	2.41	0.52	0.63	1.64
Total	99.87	99.85	100.47	99.87	100.13	100.16
CIPW norm:						
qz	22.98	4.44	0.00	33.06	12.67	?
or	18.90	5.56	11.00	27.80	4.37	?
ab	32.49	27.25	25.76	34.06	35.96	?
an	15.29	17.51	17.72	2.50	32.96	?
ne	0.00	0.00	6.95	0.00	0.00	?
di	0.00	15.75	14.40	0.30	2.93	?
en (hy)	6.82	16.04	0.00	0.92	4.52	?
ol	0.00	0.00	9.92	0.00	0.00	?
mt	0.93	4.41	5.10	0.46	4.64	?
il	0.91	6.54	4.63	0.15	1.21	?
ap	0.34	1.68	1.62	0.00	0.24	?

*LOI = loss on ignition (generally H_2O + CO_2).



Ks: kalsilite
Lc: leucite
Sa: sanidine
Tr: tridymite
Cr: cristobalite
L: liquid (melt)