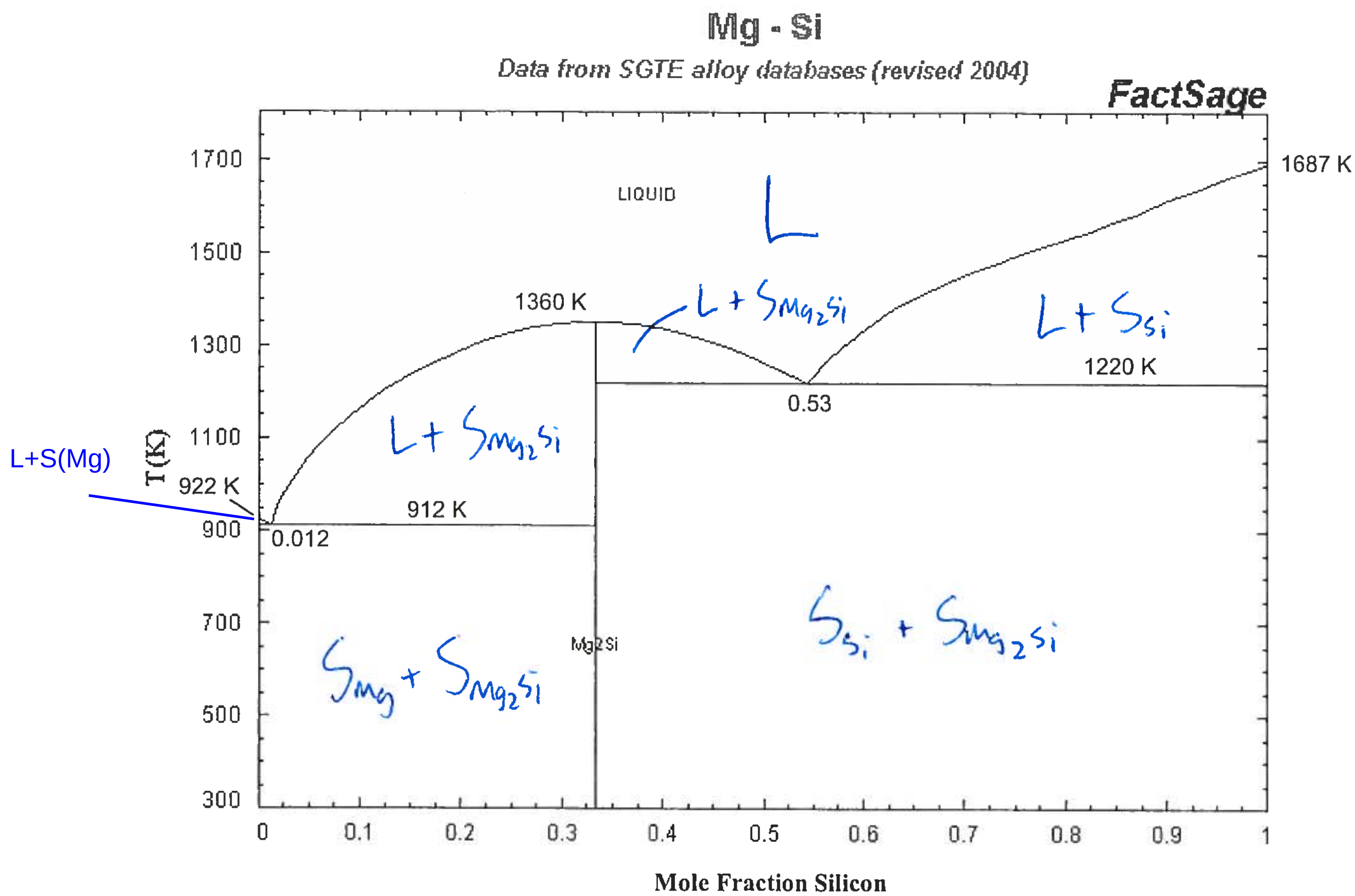
Question Number IV *(25 Marks ~ 30 minutes)*

Use the phase diagram to answer the following questions. The molar mass of magnesium is 24.3 kg/kmol and that of silicon is 28.1 kg/kmol. Note that the vertical line at 0.3333 mole fraction silicon represents the solid compound Mg_2Si.



a) Label all of the single and two phase regions on the diagram. (/2)

see diagram

b) What is the melting temperature of pure silicon? (/1)

$T = 1687\text{ K}$

c) What is the freezing temperature of a mixture with 47mol% magnesium? (/1)

$X_{Si} = 0.53$ $T = 1220\text{ K}$

d) What is the maximum solubility of silicon in magnesium? (/1)

$X_{Si} = 0$

e) A mixture that contains 30mol% magnesium and 70mol% silicon (100 kmol total) initially at 1700 K is slowly cooled.

i) What is the mass fraction of magnesium in the mixture initially at 1700 K? (/4)

$X_{mg} = 0.30$ $\quad W_{mg} = ?$

$\downarrow$

1 kmol

$W_{mg} = \frac{7.29 \text{ kg}}{26.96 \text{ kg}} = \boxed{0.27}$

0.3 kmol Mg × 24.3 kg/kmol = 7.29 kg
0.7 kmol Si × 28.1 kg/kmol = 19.67 kg
26.96 kg

ii) At what temperature would a second phase appear? (/1)

1450 K

iii) What is the composition (mol fraction Si) of the phase that appears? (/1)

$X_{Si} = 1.0$

iv) The mixture is further cooled to 1300 K. Determine the masses (kg) of the two phases present. (/5)

L — MIX — S

0.58 — 0.70 — 1.0 $\quad$ Si (X_{Si})

$\frac{n_L}{n_T} = \frac{1-0.7}{1-0.58} = 0.714$ $\quad$ 0.714 × 100 kmol = 71.4 kmol LIQ
28.6 kmol VAP

LIQ $\quad$ 71.4 kmol × 0.58 = 41.412 kmol Si × 28.1 = 1163.6772 kg
× 0.42 = 29.988 kmol Mg × 24.3 = 728.7084 kg

$\boxed{1892.38 \text{ kg LIQ}}$

SOLID $\quad$ 28.6 kmol × 1.0 = 28.6 kg Si

28.6 × 28.1 kg = $\boxed{803.66 \text{ kg SOLID}}$

f) A mixture that contains 30mol% magnesium and 70mol% silicon (100 kmol total) is initially at 1300 K. Magnesium is added until only a single phase exists. Determine the minimum amount (kmol) of magnesium added. (/5)

new $X_{Si} = 0.58 = \frac{n_{Si}}{n_T} = \frac{70 \text{ kmol}}{100 \text{ kmol} + n_{Mg\,added}}$

$0.58 = \frac{70}{100 + n_{Mg\,added}}$

$0.58(100 + n_{Mg\,added}) = 70$

$58 + 0.58\, n_{Mg\,added} = 70$

$\boxed{n_{Mg\,added} = 20.69 \text{ kmol}}$

g) A container holds 5 kmol of Si and 5 kmol of Mg at 700 K.

i) This mixture is heated. At what temperature does the first drop of liquid appear? (/1)

1220 K

ii) What is the composition of this liquid? (/1)

$X_{Si} = 0.53$

iii) The mixture continues to be heated. At what temperature does the mixture become all liquid? (/1)

~1260 K

iv) What is the composition of the last remaining solid just before it becomes all liquid? (/1)

$X_{Si} = 0.33$