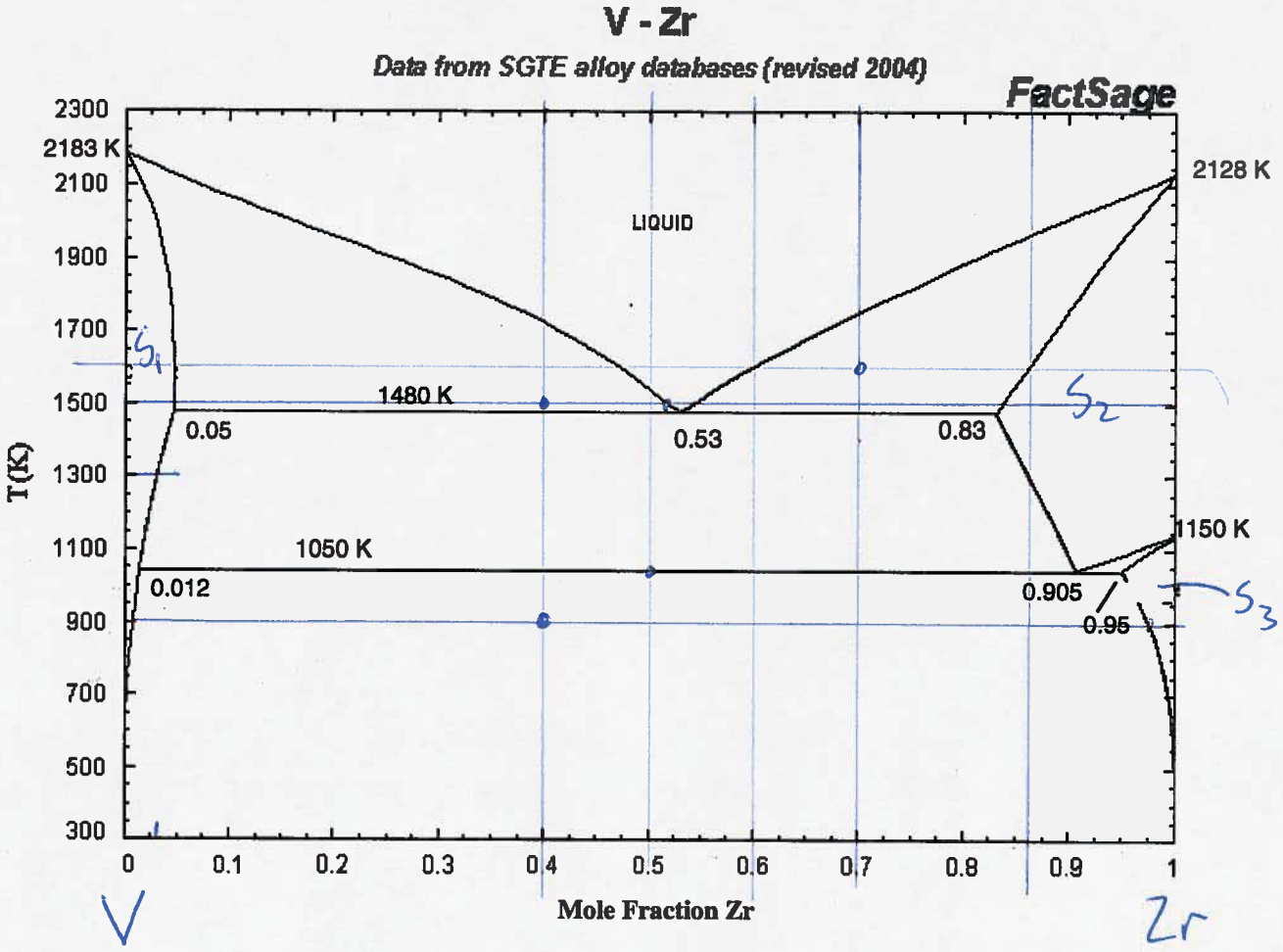
Question Number IV *(25 Marks ~ 30 minutes)*

Use the phase diagram to answer the following questions. The molar mass of vanadium (V) is 50.94 kg/kmol and that of zirconium (Zr) is 91.22 kg/kmol.



a) What is the eutectic composition and temperature? (/1)

$T = 1480\,K, \quad X_{Zr} = 0.53$

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

$T = 2183\,K$

c) Identify the phases (be specific) and their compositions for an equimolar mixture of Zr and V held at 1050K. (/3)

solid 1 $X_{Zr} = 0.012$
solid 2 $X_{Zr} = 0.905$
solid 3 $X_{Zr} = 0.95$

d) A container holds 127.7 kg of zirconium and 30.6 of vanadium initially at 2300K. The mixture is slowly cooled to 1600K. kg

i. What is the mass fraction of zirconium in the initial mixture? (/2)

$M_T = 127.7 + 30.6 = 158.3$ kg

$W_{Zr} = \frac{127.7}{158.3} = 0.807$

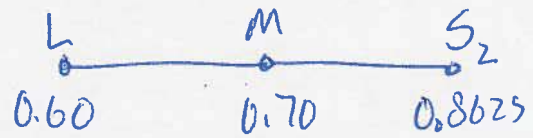
ii. What is the mole fraction of zirconium in the initial mixture? (/3)

$n_{Zr} = \frac{127.7 \text{ kg}}{91.22 \text{ kg/kmol}} = 1.40 \text{ kmol}$ $\quad X_{Zr} = \frac{1.4}{2} = 0.70$

$n_V = \frac{30.6}{50.94} = 0.60$

$n_T = 2$ kmol

iii. Determine the mass of liquid in the container at 1600K. (/3) /6



$\frac{n_L}{n_T} = \frac{0.8625 - 0.7}{0.8625 - 0.6} = 0.619$

$n_L = 0.619\,(2 \text{ kmol}) = 1.238$ kmol L

$1.238 \text{ kmol L} \times 0.60 = 0.7428$ kmol Zr

0.4951 kmol V

$0.7428 \times 91.22 = 67.76$ kg Zr

$0.4951 \times 50.94 = 25.22$ kg V

$> = 92.98$ kg L

e) A separate container holds 8 kmol of zirconium and 12 kmol of vanadium at 900 K.

i. Identify the phases (be specific) and their compositions. (/2) / 3

$X_{Zr} = \frac{8}{20} = 0.40$ Solid 1 $X_{Zr} = 0.0001$

Solid 3 $X_{Zr} = 0.975$

ii. The mixture is slowly heated. At what temperature would the first liquid appear? (/1)

1480K

iii. What would be the composition of the first drop of liquid at the temperature in ii? (/1)

$X_{Zr} = 0.53$

iv. The mixture is further heater to 1500 K. Determine how much (kmol) zirconium would have to be added to obtain a single phase (/4)

$X_{Zr} = 0.525$ when one phase

$$X_{Zr} = 0.525 = \frac{n_{Zr}}{n_T} = \frac{8 + n_{Zr\,added}}{20 + n_{Zr\,added}}$$

$$0.525(20 + n) = 8 + n$$

$$10.5 + 0.525n = 8 + n$$

$$2.5 = 0.475n$$

$$n = 5.26 \text{ kmol}$$