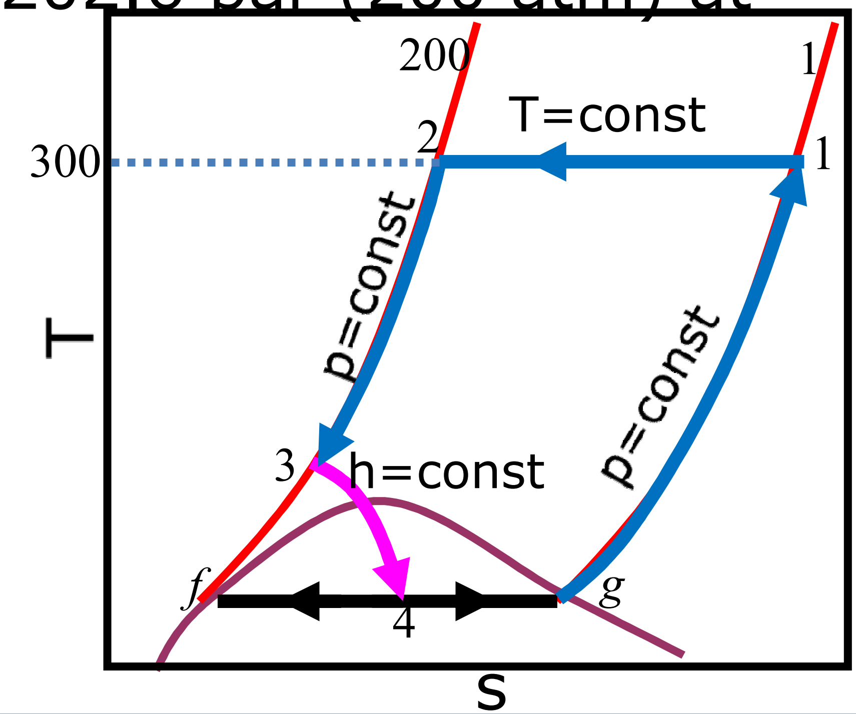
Tutorial – 1

- Determine the liquid yield, the work per unit mass compressed and work for unit mass liquefied for a Linde – Hampson cycle with air as working fluid. The system is operated between 1.013 bar (1 atm) and 202.6 bar (200 atm) at 300 K.

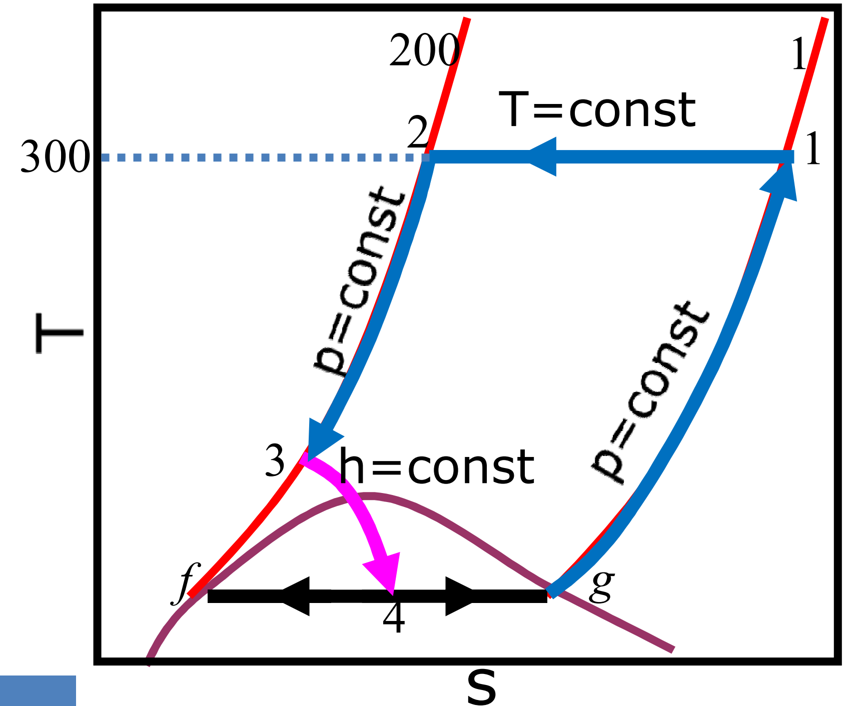
- **Step 1**

- The T – s diagram for a Linde – Hampson Cycle is as shown.



Tutorial – 1

- **Step 2**
- The state properties at different points are as given below.
- The properties are taken from NIST.

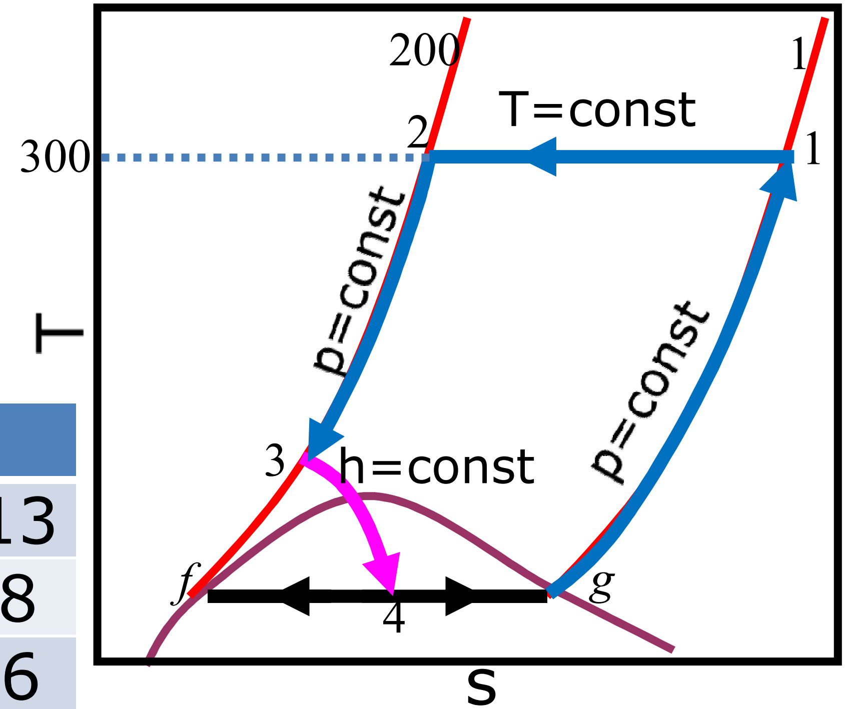


	1	2	f
p (bar)	1.013	202.6	1.013
T (K)	300	300	78.8
h (J/g)	28.47	-8.37	-406
s (J/gK)	0.10	-1.5	-3.9

Tutorial – 1

- **Liquid yield**

$$y = \left(\frac{h_1 - h_2}{h_1 - h_f} \right)$$



	1	2	f
p (bar)	1.013	202.6	1.013
T (K)	300	300	78.8
h (J/g)	28.47	-8.37	-406
s (J/gK)	0.10	-1.5	-3.9

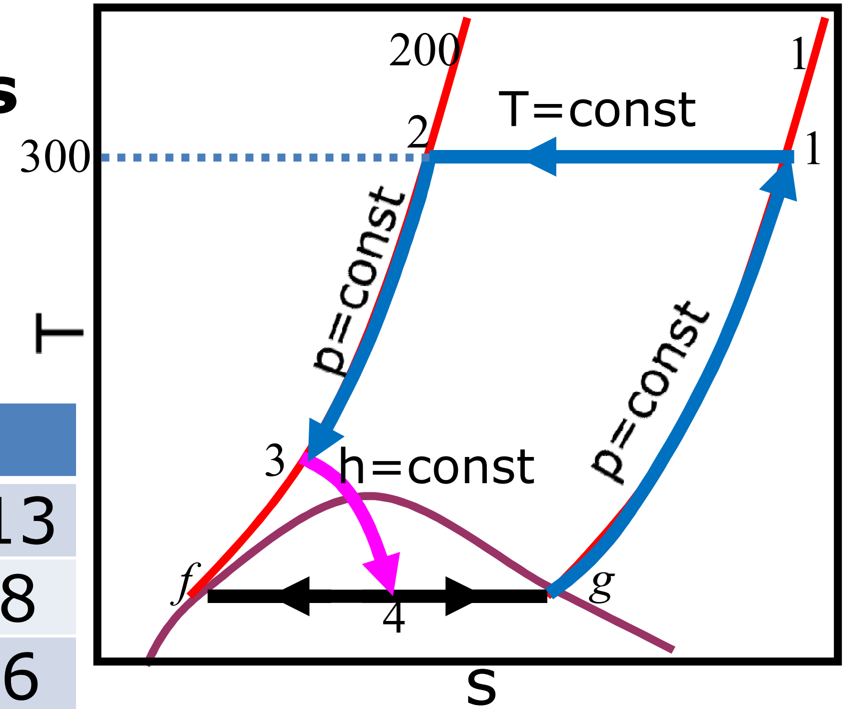
$$y = \left(\frac{h_1 - h_2}{h_1 - h_f} \right) = \left(\frac{28.47 + 8.37}{28.47 + 406} \right) = \left(\frac{36.84}{434.47} \right) = 0.085$$

Tutorial – 1

- **Work/unit mass of gas compressed**

$$-\frac{W_c}{\dot{m}} = T_1\left(s_1 - s_2\right) - \left(h_1 - h_2\right)$$

	1	2	f
p (bar)	1.013	202.6	1.013
T (K)	300	300	78.8
h (J/g)	28.47	-8.37	-406
s (J/gK)	0.10	-1.5	-3.9



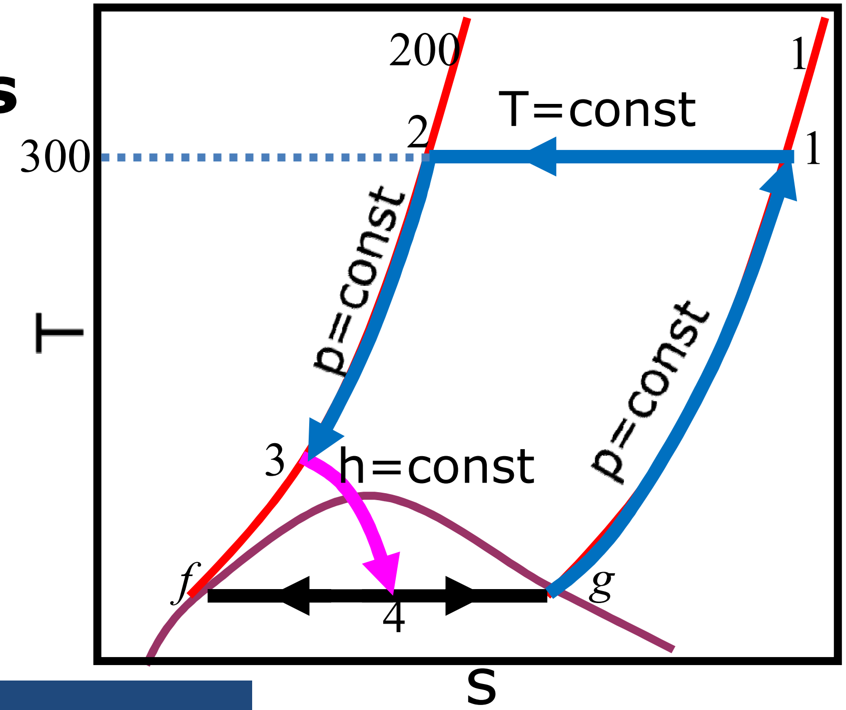
$$-\frac{W_c}{\dot{m}} = 300\left(0.1+1.5\right) - \left(28.47+8.37\right) = 443.16\ J/g$$

Tutorial – 1

- **Work/unit mass of gas liquefied**

$$-\frac{W_c}{\dot{m}} = 443.16$$

$$y = 0.085$$

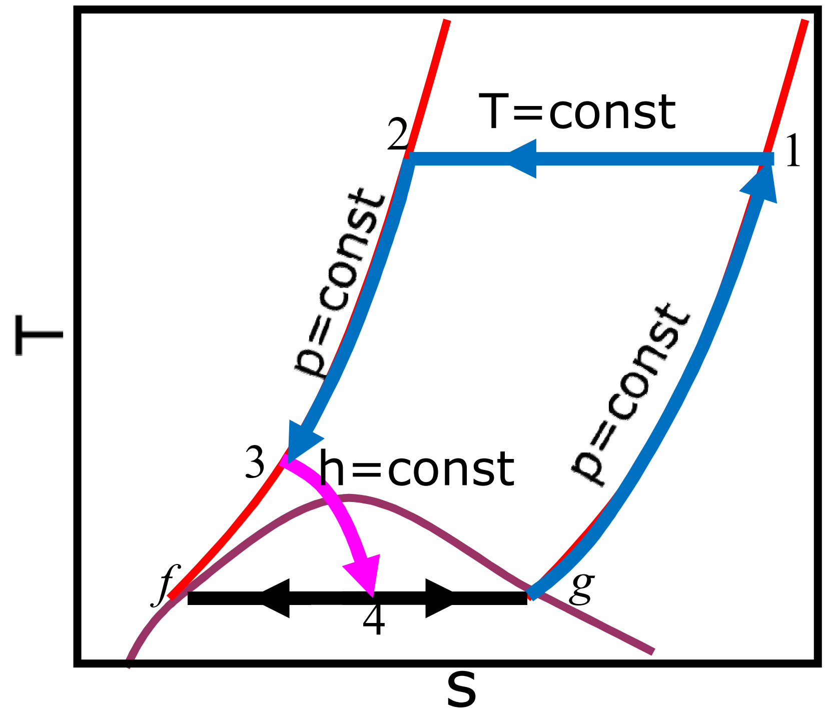


$$-\frac{W_c}{\dot{m}_f} = -\frac{W_c}{y\dot{m}} \quad = \frac{443.16}{0.085} \quad = 5213.64\ J/g$$

Tutorial – 2

- Determine the liquid yield for a Linde – Hampson cycle with Nitrogen as working fluid for the following operating conditions. Comment on the results.

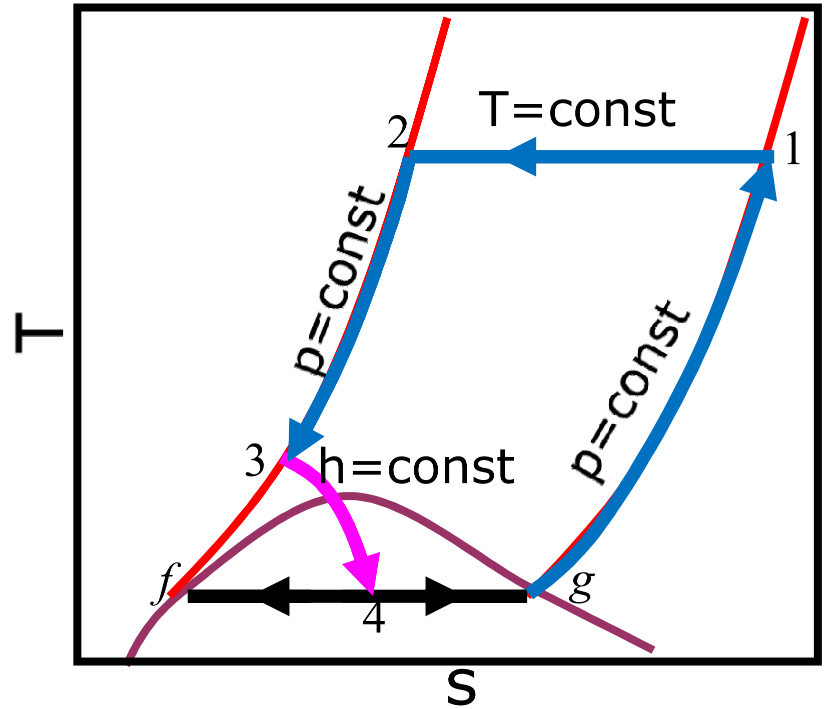
	Point 1	Point 2
I	300 K, 1 bar	300 K, 50 bar
II	200 K, 1 bar	200 K, 50 bar
III	300 K, 1 bar	300 K, 100 bar
IV	200 K, 1 bar	200 K, 100 bar



Tutorial – 2

Step : 1

- Assuming the heat exchange process to 100% effective, the T – s diagram for a Linde – Hampson Cycle is as shown.

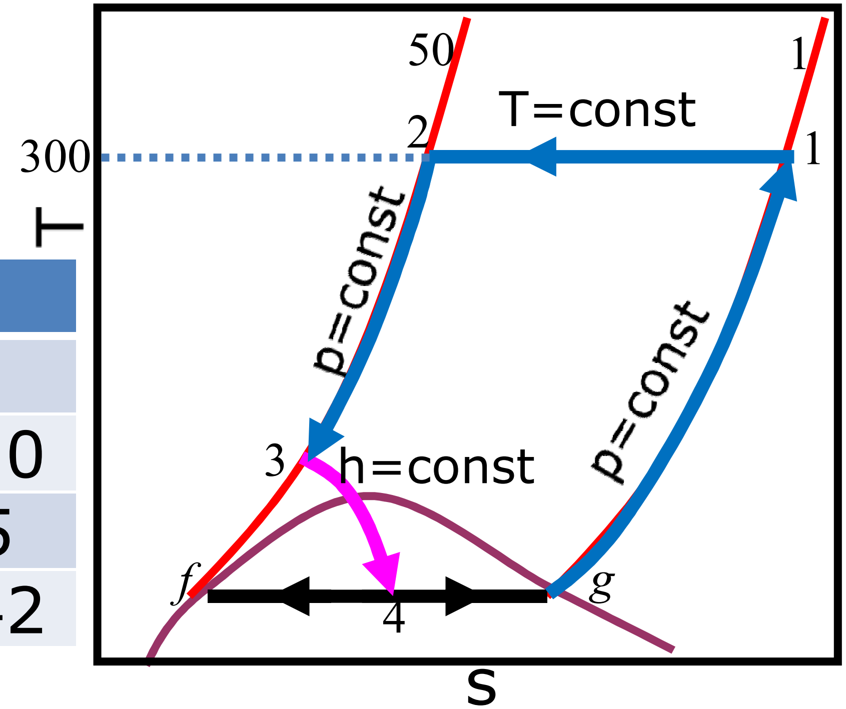


- In this tutorial , we assume that 1 atm = 1 bar.

Tutorial – 2

	Point 1	Point 2
I	300 K, 1 bar	300 K, 50 bar

	1	2	f
p (bar)	1	50	1
T (K)	300	300	77.0
h (J/g)	464	454	35
s (J/gK)	4.35	3.25	0.42

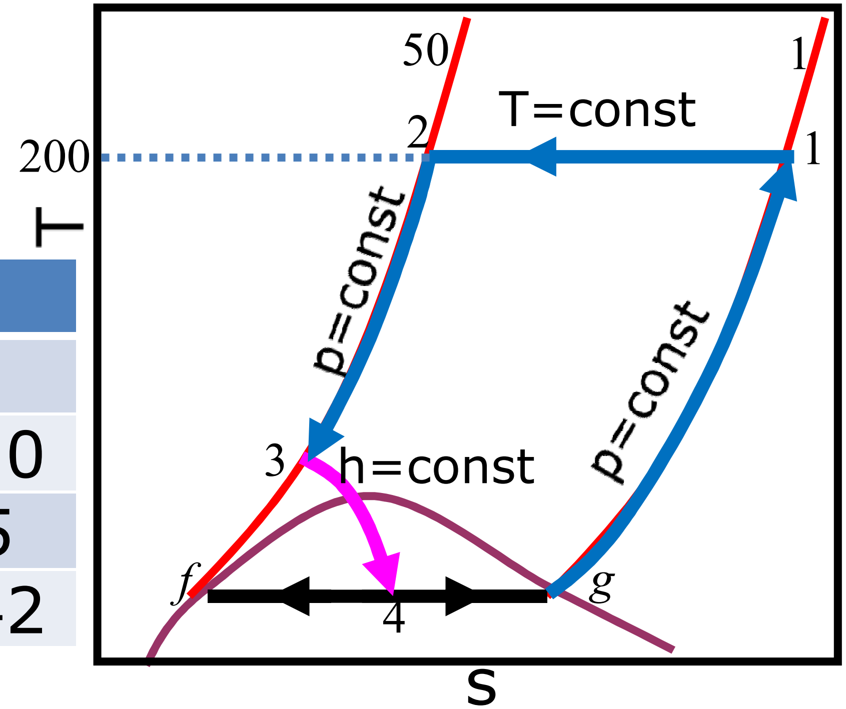


$$y_I = \left(\frac{h_1 - h_2}{h_1 - h_f}\right) = \left(\frac{464 - 454}{464 - 35}\right) = \left(\frac{10}{429}\right) = 0.023$$

Tutorial – 2

	Point 1	Point 2
II	200 K, 1 bar	200 K, 50 bar

	1	2	f
p (bar)	1	50	1
T (K)	200	200	77.0
h (J/g)	357	332	35
s (J/gK)	4.0	2.8	0.42

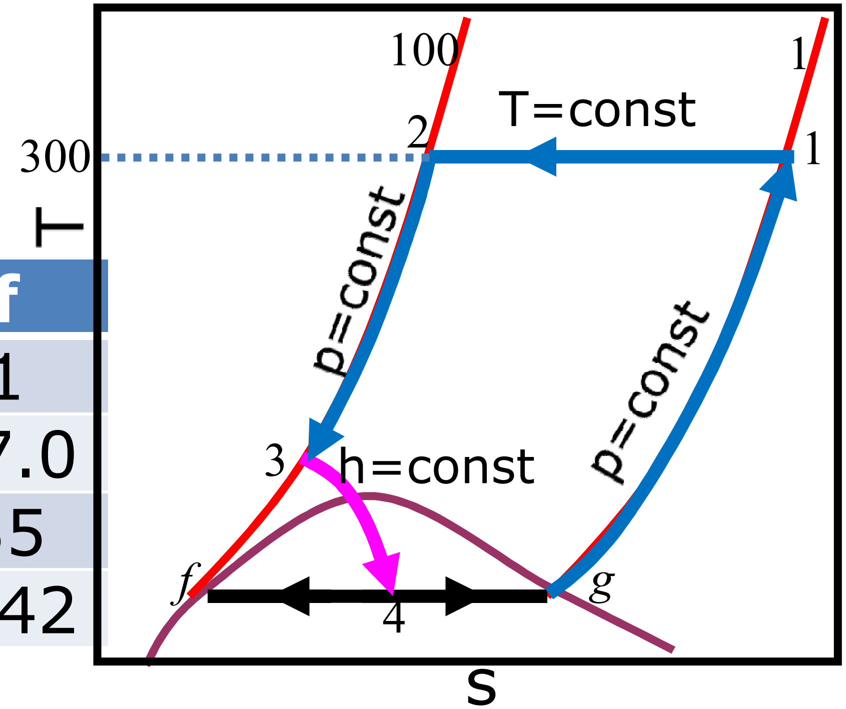


$$y_{II} = \left(\frac{h_1 - h_2}{h_1 - h_f} \right) = \left(\frac{357 - 332}{357 - 35} \right) = \left(\frac{25}{325} \right) = 0.076$$

Tutorial – 2

	Point 1	Point 2
III	300 K, 1 bar	300 K, 100 bar

	1	2	f
p (bar)	1	100	1
T (K)	300	300	77.0
h (J/g)	464	445	35
s (J/gK)	4.35	3.1	0.42

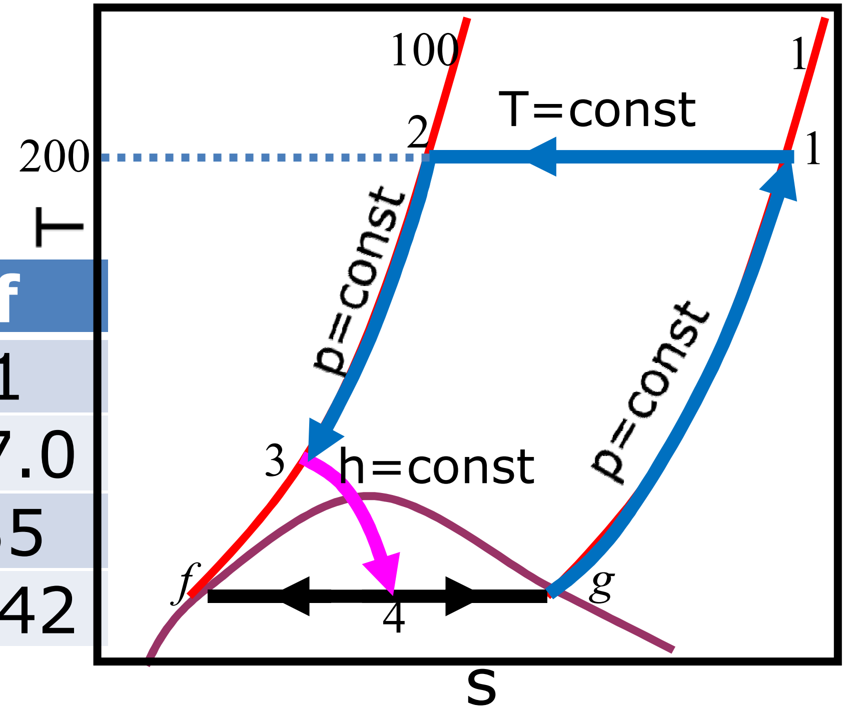


$$y_{III} = \left(\frac{h_1 - h_2}{h_1 - h_f}\right) = \left(\frac{464 - 445}{464 - 35}\right) = \left(\frac{19}{429}\right) = 0.044$$

Tutorial – 2

	Point 1	Point 2
IV	200 K, 1 bar	200 K, 100 bar

	1	2	f
p (bar)	1	100	1
T (K)	200	200	77.0
h (J/g)	357	312	35
s (J/gK)	4.0	2.5	0.42



$$y_{IV} = \left(\frac{h_1 - h_2}{h_1 - h_f}\right) = \left(\frac{357 - 312}{357 - 35}\right) = \left(\frac{45}{322}\right) = 0.14$$

Tutorial – 2

	Point 1	Point 2	y
I	300 K, 1 bar	300 K, 50 bar	0.023
II	200 K, 1 bar	200 K, 50 bar	0.076
III	300 K, 1 bar	300 K, 100 bar	0.044
IV	200 K, 1 bar	200 K, 100 bar	0.14

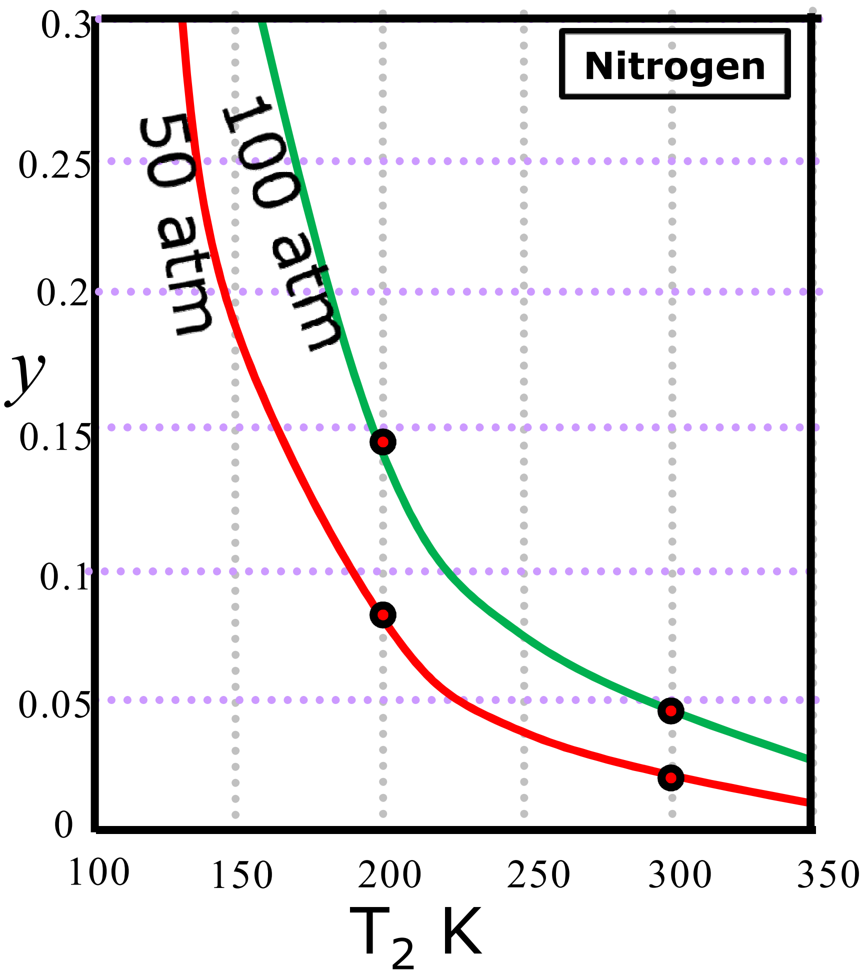
- As the compression pressure increases, the liquid yield **y** increases at a given compression temperature.

Tutorial – 2

	Point 1	Point 2	y
I	300 K, 1 bar	300 K, 50 bar	0.023
II	200 K, 1 bar	200 K, 50 bar	0.076
III	300 K, 1 bar	300 K, 100 bar	0.044
IV	200 K, 1 bar	200 K, 100 bar	0.14

- As the compression temperature decreases, the liquid yield **y** increases at a given compression pressure.

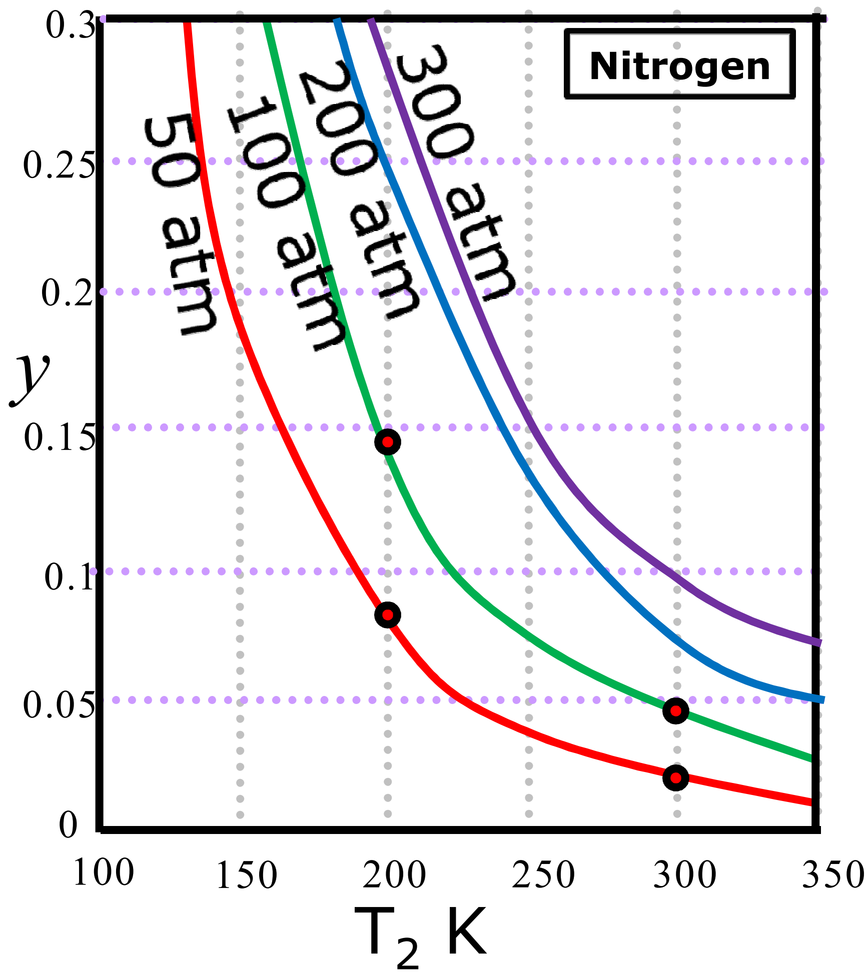
Liquid Yield : Nitrogen



- Plotting the values for the following conditions, we have

	Point 2	y
I	300 K, 50 bar	0.023
II	200 K, 50 bar	0.076
III	300 K, 100 bar	0.044
IV	200 K, 100 bar	0.14

Liquid Yield : Nitrogen



- Summarizing, we have
- As the compression pressure increases, the liquid yield **y** increases at a given compression temperature.
- As the compression temperature decreases, the liquid yield **y** increases at a given compression pressure.