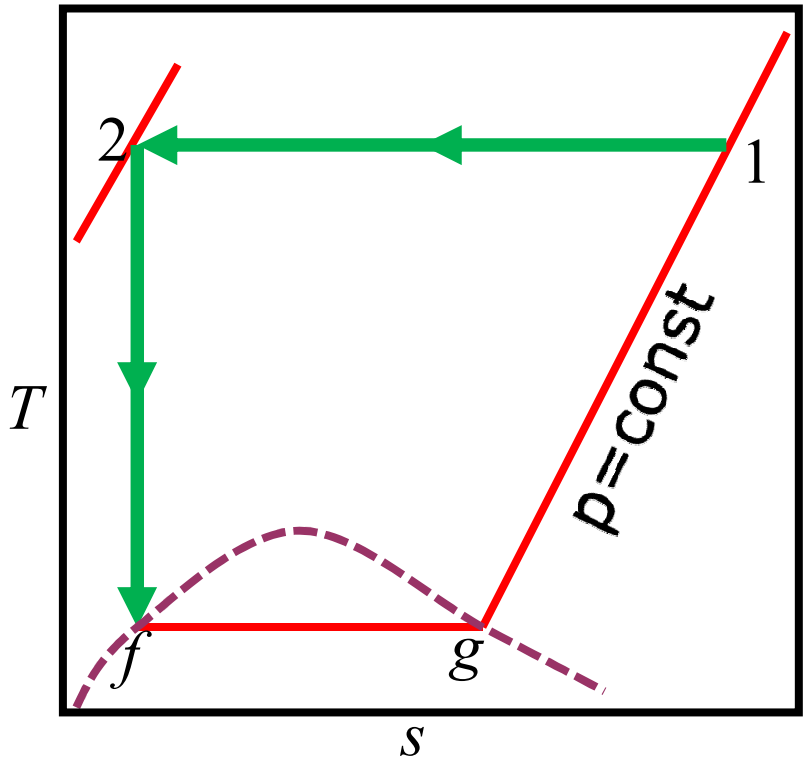
Tutorial – 1

- Determine the ideal work requirement for liquefaction of nitrogen beginning at 1 bar pressure and 300 K.

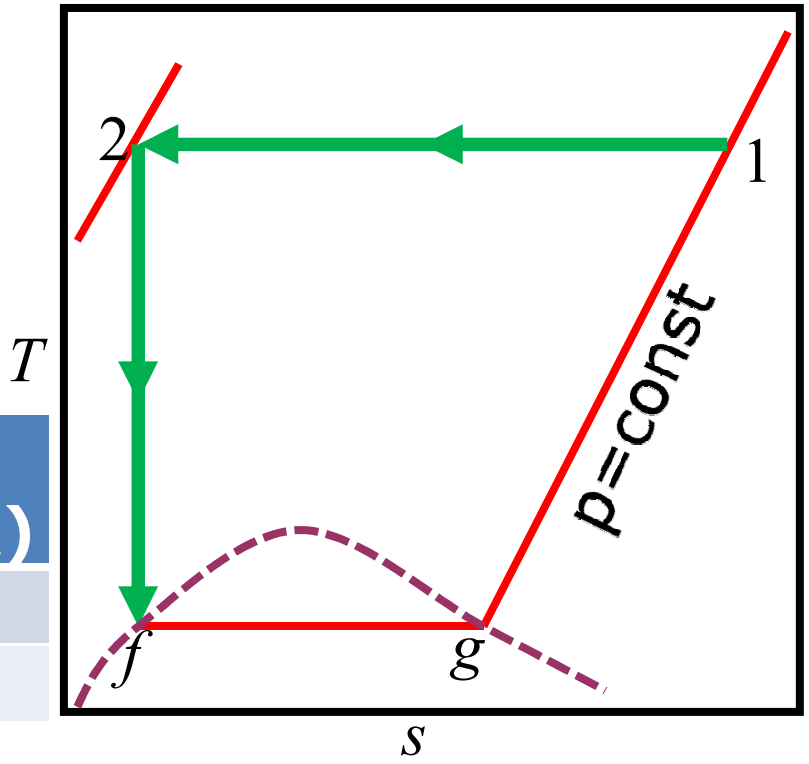
- **Step 1**
- The T – s diagram for an ideal thermodynamic cycle is as shown



Tutorial – 1

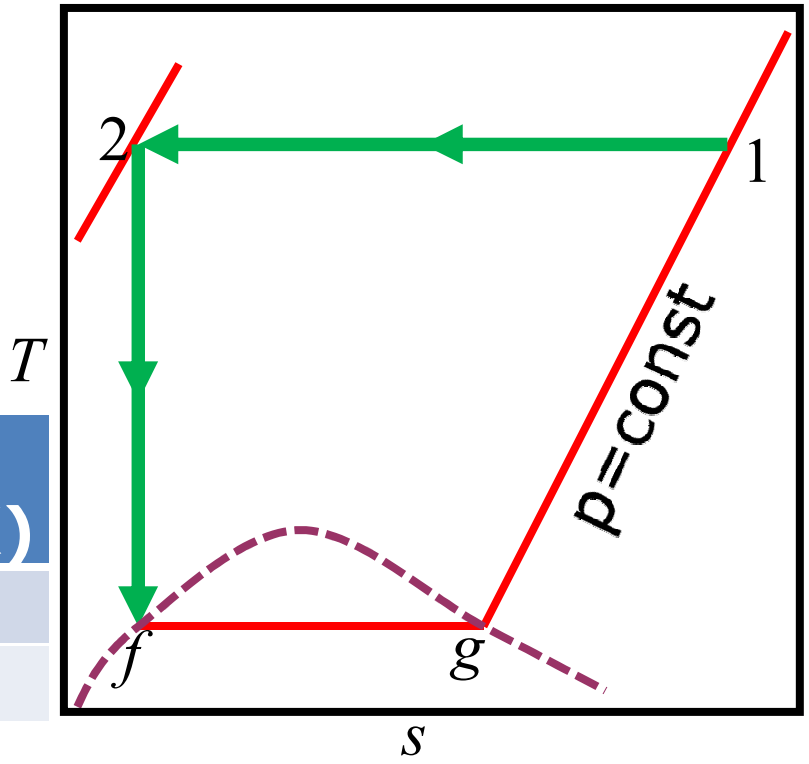
- **Step 2**
- The state properties at different points are as given below.

	p (bar)	T (K)	h (J/g)	s (J/gK)
1	1	300	462	4.42
f	1	77	29	0.42



Tutorial – 1

- **Step 3**
- Substitution into the equation.



	p (bar)	T (K)	h (J/g)	s (J/gK)
1	1	300	462	4.42
f	1	77	29	0.42

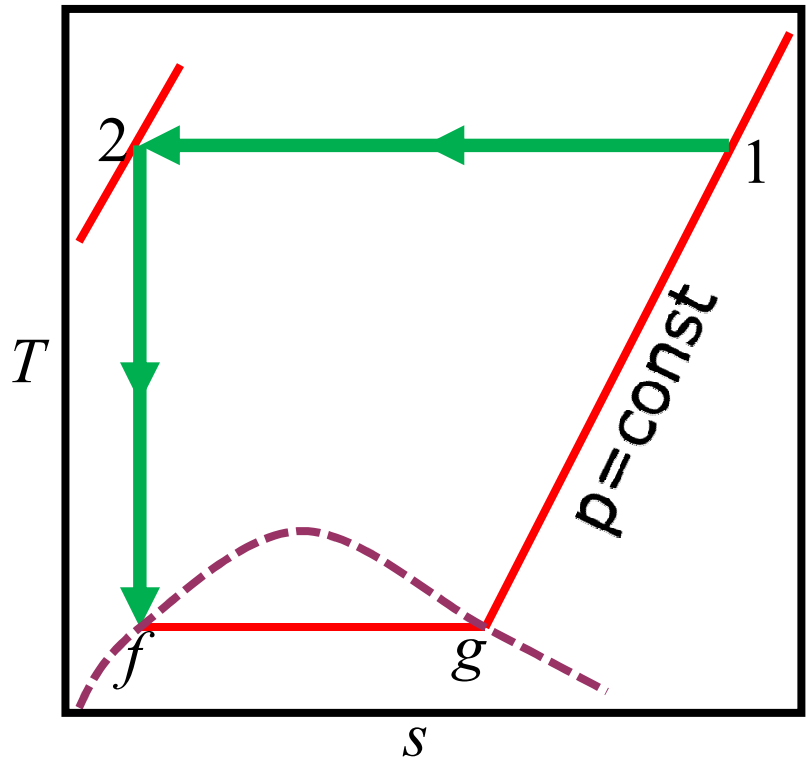
$$-\frac{\dot{W}_i}{\dot{m}_f} = T_1\left(s_1 - s_f\right) - \left(h_1 - h_f\right)$$

$$= 300(4.42 - 0.42) - (462 - 29) = 767\, J/g$$

Tutorial – 2

- Calculate the ideal work requirement for liquefaction of Helium and Hydrogen beginning at 1 bar pressure and 300 K. Compare the results.

- **Step 1**
- The T – s diagram for an ideal thermodynamic cycle is as shown



Tutorial – 2

- **Step 2**
- The state properties for hydrogen and Helium at different points are as given below.

	p (bar)	T (K)	h (J/g)	s (J/gK)
Hydrogen				
1	1	300	4190	65
f	1	20	-75	18
Helium				
1	1	300	1575	31.5
f	1	4.2	9.5	3.45

Tutorial – 2

- **Step 3**
- Substitution into the equation.

$$-\frac{\dot{W}_i}{\dot{m}_f} = T_1\left(s_1 - s_f\right) - \left(h_1 - h_f\right)$$

	p (bar)	T (K)	h (J/g)	s (J/gK)
Hydrogen				
1	1	300	4190	65
f	1	20	-75	18
Helium				
1	1	300	1575	31.5
f	1	4.2	9.5	3.4

H_2

$$= 300(65 - 18) - (4190 + 75)$$
$$= 9835\, J/g$$

He

$$= 300(31.5 - 3.4) - (1575 - 9.5)$$
$$= 6864.5\, J/g$$

Ideal Work Requirement

Gas	Normal Boiling Point (K)	Ideal Work (kJ/Kg)
Helium	4.21	6819
Hydrogen	20.27	12019
Nitrogen	77.36	768.1
Air	78.8	738.9
Argon	87.28	478.6
Oxygen	90.18	635.6
Ammonia	239.8	359.1