

國立成功大學

112學年度碩士班招生考試試題

編 號： 138、165

系 所： 航空太空工程學系
能源工程國際碩士學位學程

科 目： 熱力學

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備 註： 不可使用計算機

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. When a fluid expands through a porous plug (or a valve) to a lower pressure is called a throttling process, which is commonly used to determine the Joule-Thomson coefficient

$$\mu_J \equiv \left(\frac{\partial T}{\partial p} \right)_h$$

since the enthalpy of the fluid remains approximately constant during such as a process.

(a). Show that μ_J is related to the constant pressure specific heat c_p (10%)

$$\mu_J = -\frac{1}{c_p} \left[v - T \left(\frac{\partial v}{\partial T} \right)_p \right]$$

(b) For a gas obeying the van der Waals equation of state, (10%)

$$p = \frac{RT}{v-b} - \frac{a}{v^2}$$

derive the expression of μ_J for this gas.

(c) Can a throttling process be used to lower the temperature of an ideal gas? Why? (5%)

(d) The throttling process, like free expansion, is irreversible, please find the entropy production in terms of pressure drop Δp . (5%)

2. (a) Show that the Gibbs function remain constant for a reversible isothermal and isobaric process. (5%)

(b) Determine the Gibbs function of formation of methane at the standard state, 25°C and 1 atm, in kJ/kmol, and compare with the value given in Table A. Explain the difference in values. (15%)

Table A Thermochemical Properties of Selected Substances at 298K and 1 atm

Substance	Formula	Molar Mass, M (kg/kmol)	Enthalpy of Formation, \bar{h}_f° (kJ/kmol)	Gibbs Function of Formation, \bar{g}_f° (kJ/kmol)	Absolute Entropy, \bar{s}° (kJ/kmol · K)	Heating Values	
						Higher, HHV (kJ/kg)	Lower, LHV (kJ/kg)
Carbon	C(s)	12.01	0	0	5.74	32,770	32,770
Hydrogen	H ₂ (g)	2.016	0	0	130.57	141,780	119,950
Nitrogen	N ₂ (g)	28.01	0	0	191.50	—	—
Oxygen	O ₂ (g)	32.00	0	0	205.03	—	—
Carbon monoxide	CO(g)	28.01	-110,530	-137,150	197.54	—	—
Carbon dioxide	CO ₂ (g)	44.01	-393,520	-394,380	213.69	—	—
Water	H ₂ O(g)	18.02	-241,820	-228,590	188.72	—	—
Water	H ₂ O(l)	18.02	-285,830	-237,180	69.95	—	—
Hydrogen peroxide	H ₂ O ₂ (g)	34.02	-136,310	-105,600	232.63	—	—
Ammonia	NH ₃ (g)	17.03	-46,190	-16,590	192.33	—	—
Oxygen	O(g)	16.00	249,170	231,770	160.95	—	—
Hydrogen	H(g)	1.008	218,000	203,290	114.61	—	—
Nitrogen	N(g)	14.01	472,680	455,510	153.19	—	—
Hydroxyl	OH(g)	17.01	39,460	34,280	183.75	—	—
Methane	CH ₄ (g)	16.04	-74,850	-50,790	186.16	55,510	50,020
Acetylene	C ₂ H ₂ (g)	26.04	226,730	209,170	200.85	49,910	48,220
Ethylene	C ₂ H ₄ (g)	28.05	52,280	68,120	219.83	50,300	47,160
Ethane	C ₂ H ₆ (g)	30.07	-84,680	-32,890	229.49	51,870	47,480
Propylene	C ₃ H ₆ (g)	42.08	20,410	62,720	266.94	48,920	45,780
Propane	C ₃ H ₈ (g)	44.09	-103,850	-23,490	269.91	50,350	46,360

3. Consider an ideal Stirling-cycle engine in which the state at the beginning of the isothermal compression process is 100 kPa, 25°C, the compression ratio is 6, and the maximum temperature in the cycle is 1100°C.

Calculate the thermal efficiency of the cycle with regenerators. (25%)

4. Cooling water leaves the condenser of a power plant and enters a wet cooling tower at 35°C at a rate of 100 kg/s. Water is cooled to 22°C in the cooling tower by air that enters the tower at 1 atm, 20°C, and 60 percent relative humidity and leaves saturated at 30°C. Neglecting the power input to the fan, determine the mass flow rate of the required makeup water. (25%)