UNIVERSITY OF GHANA

FIRST SEMESTER EXAMINATIONS: 2016/2017

SCHOOL OF ENGINEERING

FAEN 205: THERMODYNAMICS (3 CREDITS)

INSTRUCTIONS: ANSWER ALL QUESTIONS

TIME ALLOWED: 2 HOURS

The Universal Gas Constants and Some of the Equations and Tables Needed are Provided on page 2.

1. Steam at 2100 KPa and 260 C expands at constant enthalpy to 125 KPa.
   a. What is the temperature of the steam in its final state?
   b. What is the entropy change
   Use steam tables for 1a and 1b

   If the steam were an ideal gas

   c. What would be the final temperature and entropy change (in J/mol K)?

   30 Marks

2. Liquid water at 25 C and 1 bar fills a rigid vessel. If heat is added to the water until its temperature reaches 50 C, What pressure is developed?
   The average value of α (coefficient of thermal expansion) and β (coefficient of compressibility) between 25 and 50 C are $36.2 \times 10^{-5} K^{-1}$ and $4.42 \times 10^{-5} bar^{-1}$, respectively. The specific volume of the liquid water at 25 C is 1.0030 cm^3/g.

   15 Marks

3. A particular power plant operates with a heat source reservoir at 623.15 K and a heat sink reservoir at 303.15 K. It has a thermal efficiency equal to 55 % of the Carnot engine thermal efficiency for the same temperatures.
   a. What is the thermal efficiency of the plant?
   b. To what temperature must the heat reservoir be raised to increase the thermal efficiency of the plant to 35 %? Again, the thermal efficiency is 55 % of the Carnot engine value.

   15 Marks

4. Calculate Z and V for ethane at 323.15 K and 15 bar by the following equations
   a. Generalized virial coefficient correlation
   b. The Soave/Redlich/Kwong (SRK) equation. ***(solve by iteration)***

Note: Ethane exist as a vapor at 323.15 K hence use the equation below

$$Z = 1 + \beta - q\beta \frac{Z - \beta}{(Z + \epsilon\beta)(Z + \sigma\beta)}$$

30 Marks

5. An ideal gas at 2500 KPa is throttled adiabatically to 150 KPa at the rate of 20 mol/s. Determine the rate of entropy generation ($\dot{S}_G$) and the rate of lost work ($\dot{W}_{lost}$).

10 Marks

P_1 2500kPa $P_2 = 150$ kPa $T = 300$ K mdot = 20 mol/s

$\Rightarrow \Delta S = -R\ln\left(\frac{P_2}{P_1}\right) = -\frac{8.314}{1000} \times \ln\left(\frac{150}{2500}\right) = 0.023$

$\dot{S}_G$ = md
= 0.

Table A.2 Values of the Universal Gas Constant

$\dot{W}$ lost

R = 8.314 J mol^{-1} K^{-1} = 8.314 m^3 Pa mol^{-1} K^{-1}
= 83.14 cm^3 bar mol^{-1} K^{-1} = 8314 cm^3 kPa mol^{-1} K^{-1}
= 82.06 cm^3 atm mol^{-1} K^{-1} = 82 363.95 cm^3 torr mol^{-1} K^{-1} = 0.082 06 m^3 atm kmol^{-1}K^{-1}
= 1.9872 (cal) mol^{-1} K^{-1} = 1.986 (Btu)(lb mole)$^{-1}$(R)$^{-1}$
= 0.7302 (ft)^3(atm)(lb mol)$^{-1}$(R)$^{-1}$ = 10.73 (ft)^3(psia)(lb mol)$^{-1}$(R)$^{-1}$
= 1545 (ft)(lb$_f$)(lb mol)$^{-1}$(R)$^{-1}$

Table 3.1: Parameter Assignments for Equations of State

For use with Eqs. (3.49) through (3.56)

Eq. of State	$\alpha(T_r)$	σ	ϵ	Ω	Ψ	Z_c
vdW (1873)	1	0	0	1/8	27/64	3/8
RK (1949)	$T_r^{-1/2}$	1	0	0.08664	0.42748	1/3
SRK (1972)	$\alpha_{SRK}(T_r; \omega)^\dagger$	1	0	0.08664	0.42748	1/3
PR (1976)	$\alpha_{PR}(T_r; \omega)^\ddagger$	$1 + \sqrt{2}$	$1 - \sqrt{2}$	0.07780	0.45724	0.30740

$^\dagger\alpha_{SRK}(T_r;\, \omega) = \left[1 + (0.480 + 1.574\,\omega - 0.176\,\omega^2)\left(1 - T_r^{1/2}\right)\right]^2$

$^\ddagger\alpha_{PR}(T_r;\, \omega) = \left[1 + (0.37464 + 1.54226\,\omega - 0.26992\,\omega^2)\left(1 - T_r^{1/2}\right)\right]^2$