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**UNIVERSITY OF TECHNOLOGY, JAMAICA**

**COLLEGE/ FACULTY: Engineering and Computing**

**SCHOOL/ DEPARTMENT: SOE/Chemical Engineering**

**Final Examination, Semester 1**

**Module Name:** Chemical Engineering Thermodynamics 1

**Module Code:** CHE3003

**Date:**  December, 2012

**Theory/ Practical:** Theory

**Groups:** B.Eng.3C

**Duration:** 2 hours

**Instructions**

1. **ANSWER ALL QUESTIONS**
2. **EACH QUESTION MUST BEGIN ON A NEW PAGE**
3. **LEAVE TWO LINES BETWEEN PARTS OF A QUESTION**
4. **READ EACH QUESTION CAREFULLY BEFORE ANSWERING**
5. **SHOW CLEARLY ALL EQUATIONS USED FOR CALCULATIONS**
6. **THE INTENDED MARK IS INDICATED AT THE BEGINNING OF EACH QUESTION**
7. **ANSWER MUST BE NUMBERED IDENTICAL TO THE QUESTION BEING ANSWERED**
8. **FORMULA SHEET, UNIT CONVERSION CHART AND PROPERTY TABLES ARE ATTACHED.**

**DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO**

**QUESTION 1 (25 marks)**

1. Four moles of an ideal gas in a piston/cylinder device is compressed isothermally but irreversibly at 160°C from 3.5 bar to 7.5 bar. The work required is 37% greater than the work of reversible, isothermal compression. The heat transferred from the gas during compression flows to a heat reservoir at 50°C. Calculate the:
2. entropy changes of the gas, **[3]**
3. entropy changes of the heat reservoir, **[7]**
4. total entropy change. **[2]**
5. A nuclear power plant generates 620 MW; the reactor temperature is 415°C and a river with water temperature of 60°C is available.
6. What is the maximum possible thermal efficiency of the plant, and what is the minimum rate at which heat must be discarded to the river? **[6]**
7. If the actual thermal efficiency of the plant is 43% of the maximum, at what rate must heat be discarded to the river, and what is the temperature rise of the river, if it has a flowrate of 305 m3/s? **[7]**

**QUESTION 2 (25 marks)**

A system consists of 2 kg of carbon dioxide initially at 1 bar and 300 K. The system undergoes a reversible power cycle consisting of the following steps:

* 1 - 2, an isochoric process to 4 bar,
* 2 - 3, polytropic expansion with an exponent of 1.28,
* 3 - 1, isobaric compression to the initial state.

Assuming that carbon dioxide follows the ideal gas model with Cp = (7/2)R and Cv = (5/2)R and neglecting kinetic and potential energy effects:

1. Sketch the cycle on a P-V diagram. **[4]**
2. Calculate the work associated with each step of the cycle. **[9]**
3. Calculate the heat associated with each step of the cycle. **[8]**
4. What is the thermal efficiency of the cycle? **[4]**

**QUESTION 3 (25 marks)**

Fifty kmol per hour of sub-cooled Toluene at 325 K and 3 bar is superheated to 650 K in a steady-flow heat exchanger. If saturation temperature (Tsat) for Toluene at 3 bar is 426.9 K, estimate the exchanger duty (in kW).

**QUESTION 4 (25 marks)**

Calculate *Z* and (m3/mol) for ethylene at 303.15 K and 8 bar by the following equations:

1. The truncated virial equation with the following experimental values of virial coefficients:

  **[8]**

1. The Soave/Redlich/Kwong (SRK) equation. **[17]**

**TOTAL MARKS =100**

**END OF PAPER**



Formula Sheet

*Truncated virial equation*

*For Vapour and Vapour-like Roots*

Start with

*For Liquid and Liquid-like Roots*

Start with

*Riedel’s equation*

Where, *P****c*** is the critical pressure in bars and *Trn* is the reduced temperature at *Tn.*

*Watson’s equation*



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