Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	PROCESS THERMODYNAMICS
COURSE CODE	:	BNL 30103
PROGRAM	:	BNL
DATE	:	DECEMBER 2014/JANUARY 2015
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 Steam is the working fluid in an ideal Rankine cycle with superheat and reheat. Steam enters the first-stage turbine at 8.00 MPa, 480 °C and expands to 0.8 MPa. It is then reheated to 400 °C before entering the second-stage turbine, where it expands to the condenser pressure of 10 kPa. The net power output is 100 MW.

(a) Draw a suitable schematic diagram representing the thermodynamic processes.

(2 marks)

(b) Describe the Rankine cycle of the steam on the given **p-h** diagram in **Figure Q1**.

(4 marks)

(c) Record the enthalpy value of the steam in each state.

(4 marks)

(d) Explain why the pump work is negligible.

(2 marks)

(e) Determine the thermal efficiency of the cycle.

(8 marks)

(f) Evaluate the effect of reheat on the steam power plant

(5 marks)

Q2 Air enters the compressor at 100 kPa, 300 K and is compressed to 1 MPa. The temperature at the first turbine stage is 1400 K. The expansion takes place isentropically in two stages, with reheat to 1400 K between the stages at a constant pressure of 300 kPa. A regenerator having an effectiveness of 100% is also incorporated in the cycle. Cp = 1.007 kJ/kgK, $\kappa = 1.4$.

(a) Draw a suitable schematic diagram of the gas turbine engine.

(3 marks)

(b) State FOUR (4) related assumptions to analyze the problem.

(2 marks)

(c) Illustrate the thermodynamic cycle of the gas turbine engine on T-s diagram.

(4 marks)

(d) Calculate the specific compressor work.

(4 marks)

(e) Calculate the specific turbines work.

(6 marks)

(f) Determine the thermal efficiency of the gas turbine engine.

(6 marks)

Q3 (a) A mixture of 4 kmol of CO, 2.5 kmol of O_2, and 8 kmol of N_2 is heated to 2600 K at a pressure of 5 atm. The equilibrium constant CO_2 is K_p = 16.461.

(i) State the function of inert gas.

(2 marks)

(ii) Write the actual stoichiometric reaction at equilibrium.

(2 marks)

(iii) Formulate the suitable material balance.

(4 marks)

(iv) Determine the equilibrium composition of the mixture.

(7 marks)

(b) In absorption refrigeration systems, a two-phase equilibrium mixture of liquid ammonia (NH_3) and water (H_2O) is frequently used. The mixture is at 40 °C. The composition of the liquid phase is 65% NH_3 and 35% H_2O by mole number.

(i) Determine the vapour pressure of water and ammonia at 40 °C.

(2 marks)

(ii) Calculate the mole fractions in the gas phase.

(4 marks)

(iii) Conclude the results you have calculated in **(ii).**

(4 marks)

Q4 Producing liquefied natural gas (LNG) can be illustrated in **Figure Q4.** Pure gas methane is in state 1 at 1 bar and 280 °C. Leaving the cooler in state 3, methane is at 100 bar and 210 K. The flash drum is adiabatic and operates at 1 bar. The compressor consists of three stages with intercooling. Each stage of compression works isentropic. The first stage compresses the gas from 1 bar to 5 bar, the second stage from 5 bar to 25 bar, and the third compressor increases

the pressure from 25 bar to 100 bar. Between each stage the gas is isobarically cooled to 280 K. Thermodynamic data are given in **Table Q4**.

(a) Show the liquefaction processes of pure methane on **p-h** diagram.

(8 marks)

(b) Determine the total compressor work through all three stages.

(6 marks)

(c) Which effect does the intercooler carry to the compressor work?

(5 marks)

(d) If 10,000 kg of gas methane is fed to LNG plant, determine the amount of methane can be liquefied?

(3 marks)

(e) Improve the plant efficiency to achieve the highest LNG of methane by modifying **Figure Q4**.

(3 marks)

- END OF QUESTIONS -

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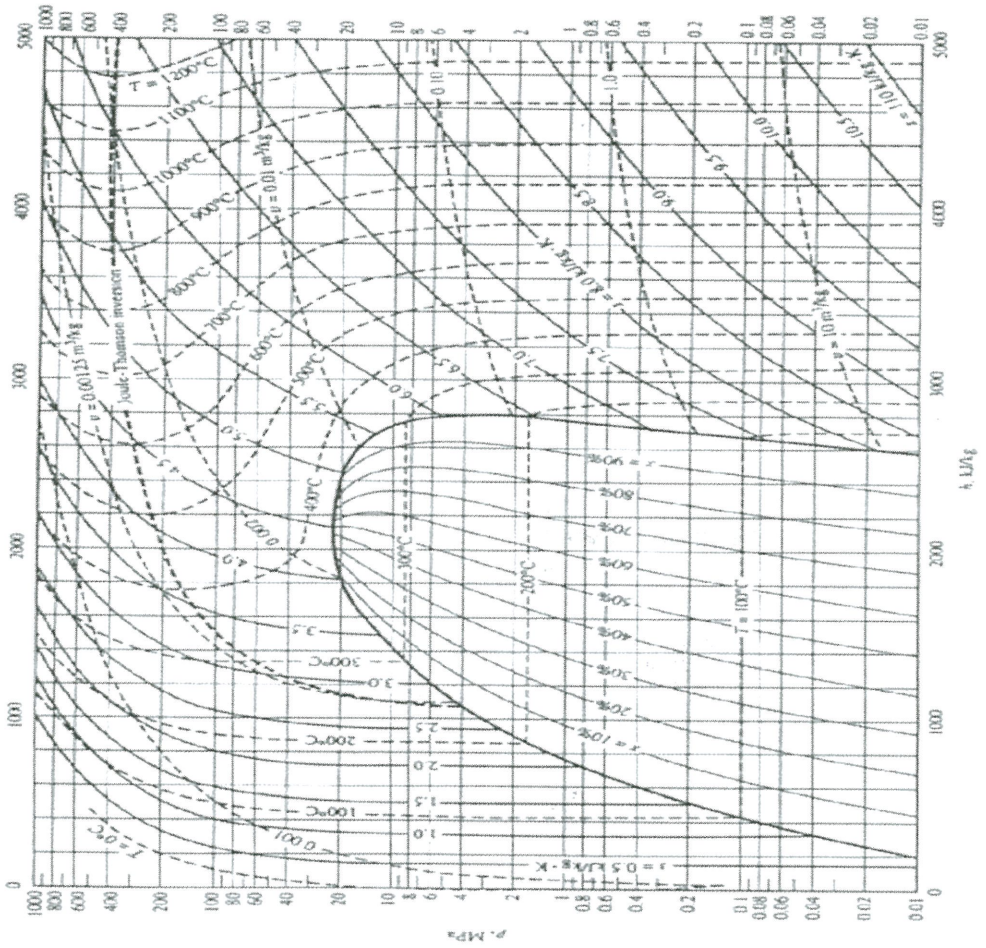

Figure Q1: p-h Diagram of Water

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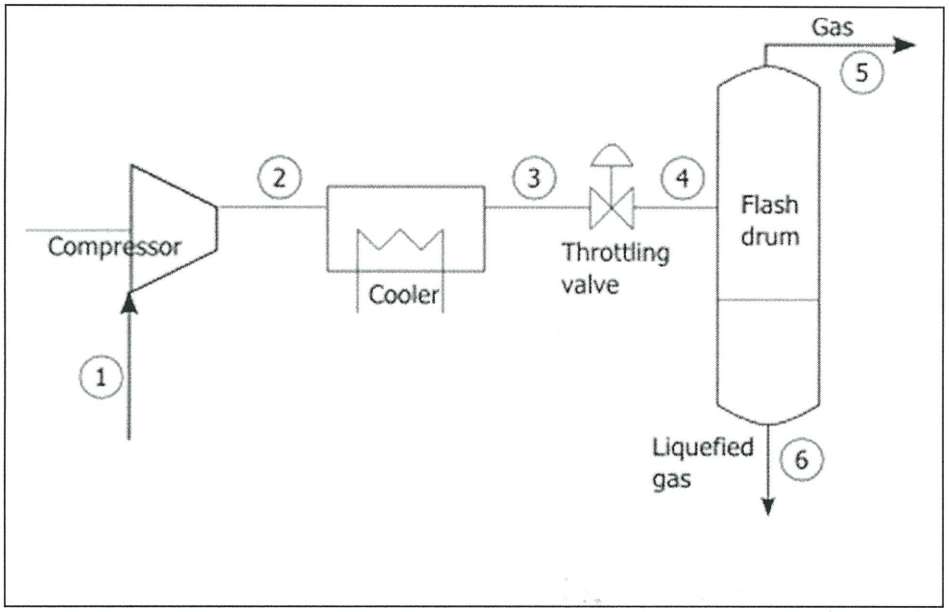

Figure Q4

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Table Q4

p [bar]	T [K]	h [kJ/kg]	s [kJ/kg K]
1	280	940	7.2
1	300	980	7.4
5	388	1195	7.2
5	280	938	6.35
5	300	990	6.5
25	386	1180	6.35
25	280	915	5.5
100	383	1140	5.5
100	210	493	3.1
1	-	71 (sat. liquid) 582 (sat. Vapor)	-
46 (critical)	190.56 (critical)	495	4.48