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UNIVERSITI KALA LUMPUR

Malaysia France Institute

FINAL EXAMINATION

JANUARY 2014 SESSION

SUBJECT CODE	:	**FRB 30203**
SUBJECT TITLE	:	**APPLIED THERMODYNAMICS**
LEVEL	:	**BACHELOR**
TIME/DURATION	:	**9.00 am – 12.00 noon (3 HOURS)**
DATE	:	**29 MAY 2014**

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This question paper consists only one section. Answer ALL questions.
6. Answer all questions in English.
7. This is an opened book examination.

THERE ARE 4 PRINTED PAGES OF QUESTIONS, EXCLUDING THIS PAGE

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

This exam is divided into two parts: Question 1 to 3 correspond to a steam turbine operating in conditions of temperature and pressure according to the Fessenheim nuclear power plant as shown in Figure 1. Questions 1 to 3 are independent of each other. Question 4 corresponds to combustion.

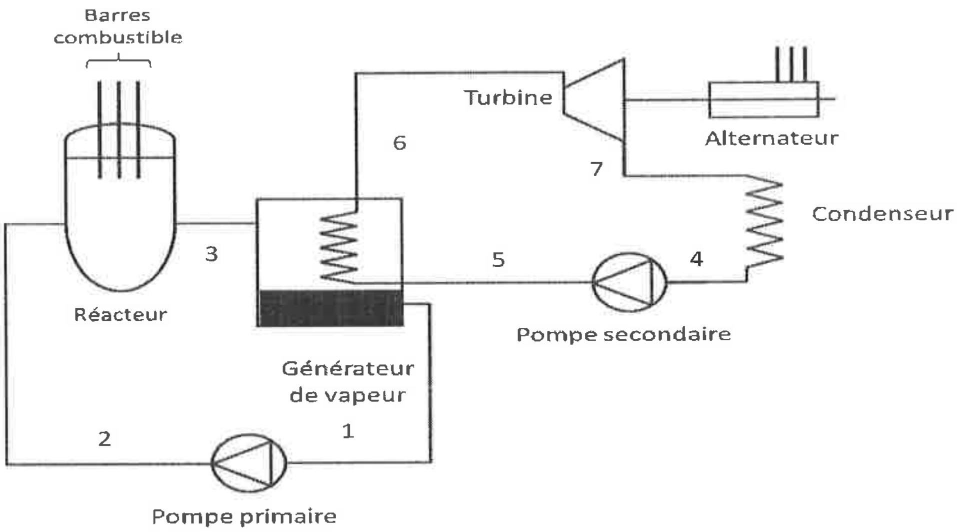

Figure 1

Question 1
Adiabatic compression of liquid water

Temperature of condenser outlet T4 is 32.5°C, liquid water is the pumped from P4 = 0.05 bar to P5 = 60bar. We assume the pump is adiabatic and reversible.
It is given that:
- *The specific volume of liquid water at 32.5°C: v '= 0.001 m3.kg-1*
- *The specific heat of liquid water at 32.5°C is equal to Cp = 4.175 kJ/kgK*
- *Coefficient of thermal expansion (β) of liquid water at 32.5°C is* $\beta = 3.210^{-4}$/K

Calculate the pump work in kJ/kg.

(2 marks)

Question 2

Nuclear reactor and steam generator (Use Figure 2 - Mollier diagram for water)

The steam generator (Generateur de vapeur) is heated by the heat from the nuclear reactor. The coolant used is liquid water that enters the pressurized reactor at T2 = 280°C and exits at T3 = 320°C to enter the steam generator at T3 = 320 ° C and out at T1 = 280 ° C. Answer these questions:

(a) Perform the energy balance on the reactor and calculate the mass flow rate ($\dot{m}_3$) of liquid water knowing that the reactor thermal power is Q_1 = 2500 MW and the Cp of liquid water between 280 ° C and 320 ° C is assumed constant and equal to 5.25kJ/kg.°C.

(2 marks)

(b) Make the energy balance of the steam generator (assuming negligible heat losses) and calculate the mass flow rate ($\dot{m}_5$) of steam generator assuming that liquid water enters the steam generator at the T4 and the steam is generated at 60bar (P6) and 300 ° C (T6).

(3 marks)

Question 3

Adiabatic expansion of the superheated steam (Use Figure 2 - Mollier diagram of water)

(a) Consider a reheated steam cycle. Initially consider an adiabatic expansion in a turbine between 60bar and 10bar. The isentropic efficiency of the turbine is equal to 0.9. Calculate the work produced per unit mass in (kJ/kg) and (kW) corresponding to the mass flow rate calculated in the question 2 (for those who have not found the mass flow rate, assume steam mass flow rate to be 1000 ton / hr).

(2 marks)

(b) On leaving the first turbine, the steam is reheated at constant pressure using heat exchanger (always 320°C) from another reactor to bring it again to 300°C. Calculate the input heat in (kJ/kg) and (kW) for the reheating by taking into account the flow rate of steam in question 2 (for those who have not found the mass flow rate, assume steam mass flow rate to be 1000 ton / hr).

(2 marks)

(c) We then consider a second expansion in another adiabatic turbine between inlet of 10 bar and outlet of 0.05 bar of the steam initially at 300 ° C. The isentropic efficiency of this 2^{nd} turbine is again equal to 0.9. Calculate the new output power in (kJ/kg) and (kW) corresponding to the mass flow rate calculated question 2 (for those who have not found the mass flow rate, assume steam mass flow rate to be 1000 ton / hr).

(2 marks)

(d) Calculate the total turbine power output produced and calculate the efficiency of this cycle. Calculate the Carnot efficiency of this cycle.

(4 marks)

Question 4

We wish to charge a mixture of CO_2/Propane (R-744/R-290) in an installation maintained at $\theta_1=15°C$ *starting* from a bottle, at θ2=*24°C*.

The charging bottle is thus at θ2=*24°C and* a pressure HP=40 bar, *it* is provided with a plunger tube making it possible to ensure the transfer in liquid phase towards the installation. The transfer is carried out until the pressure in the installation reaches *BP=25 bar*, this installation being maintained at θ1=*15°C*. Answer these questions.

(a) To locate on Figure 3 (to return the figure with the answer sheet) zones of pure liquid and pure vapour as well as the curves of dew and bubble of each spindle.

(1 mark)

(b) To calculate the concentrations in liquid phase and vapour phase in the bottle of supply (*HP=40 bar and θ2=24°C).*

(2 marks)

(c) To calculate the concentrations in liquid phase and vapour phase in the installation *(BP=25 bar and θ1=15°C).*

(2 marks)

Feuille à retourner avec la copie d'examen

N° de copie: ……………………………………

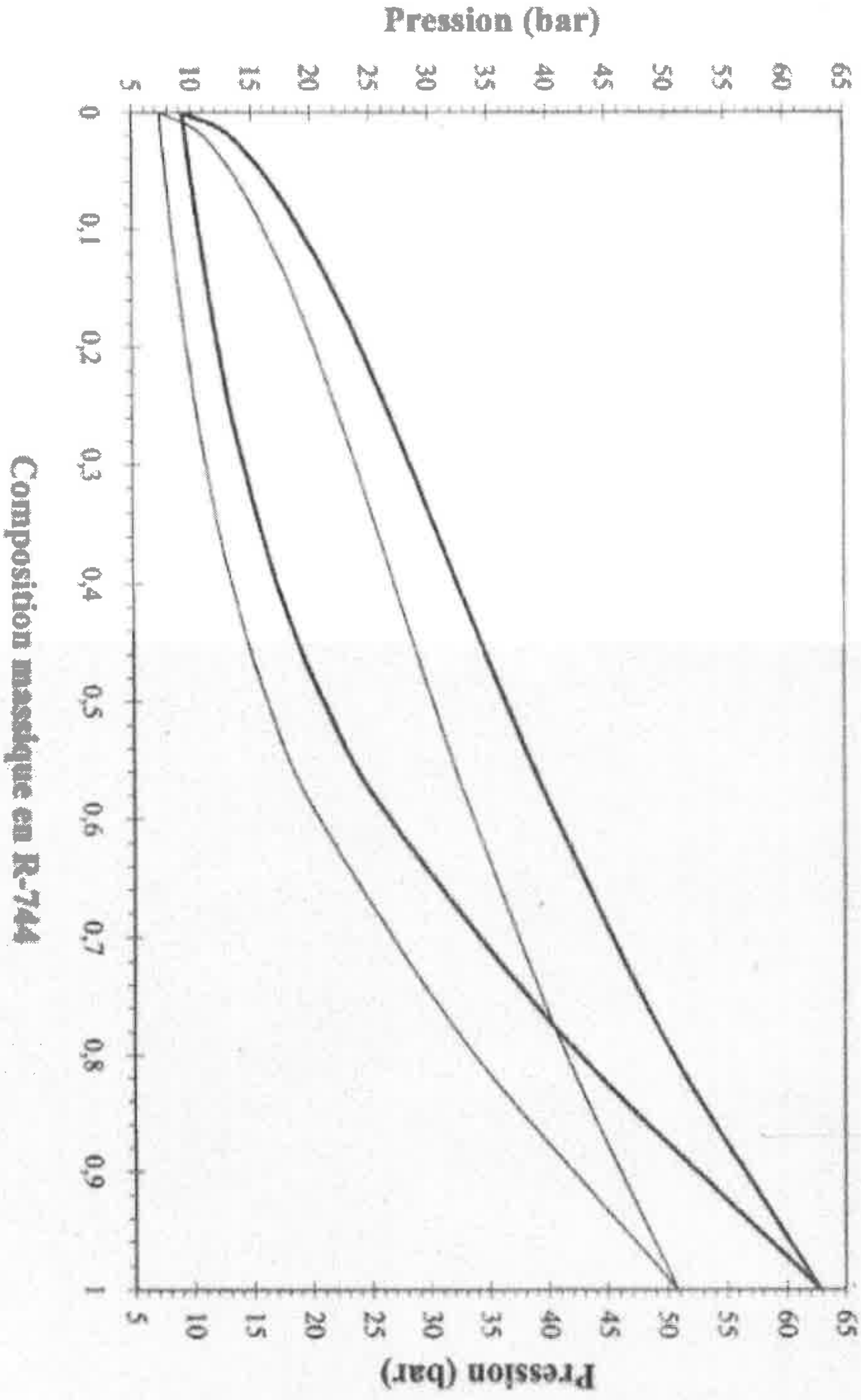

Figure 3 : Diagramme d'équilibre des phases du couple CO_2/Propane (R-744/R-290)

END OF QUESTIONS

APPENDIX

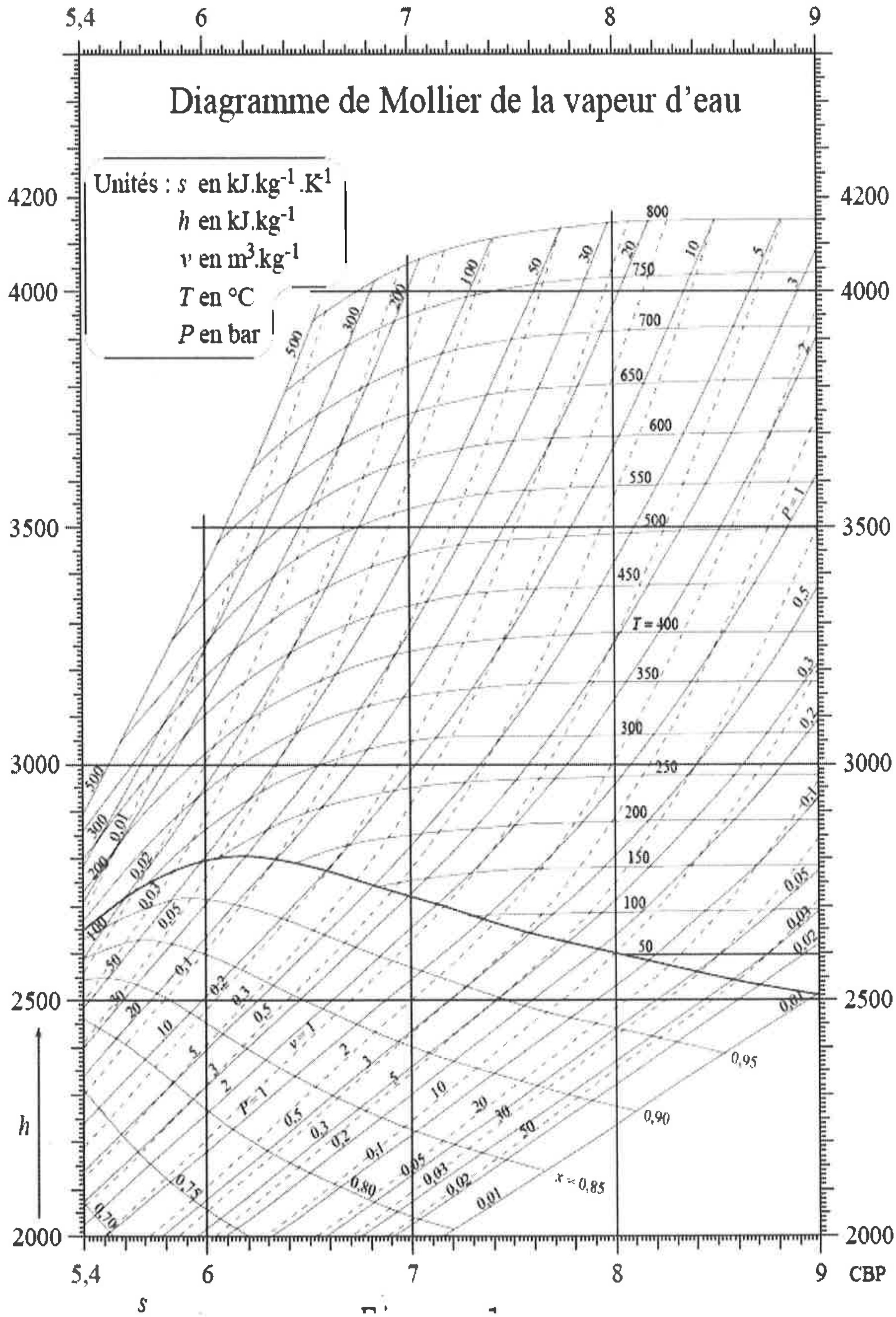
Diagramme de Mollier de la vapeur d'eau
Unités : s en kJ.kg-1.K-1
h en kJ.kg-1
v en m3.kg-1
T en °C
P en bar
5,4
6
7
8
9
4200
4000
3500
3000
2500
2000
800
750
700
650
600
550
500
450
T = 400
350
300
250
200
150
100
50
P = 1
v = 1
x = 0,85
0,90
0,95
0,80
0,75
0,70
h
s
CBP

Figure 2