CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
SEPTEMBER 2014 SESSION

SUBJECT CODE	:	**NMB31403**
SUBJECT TITLE	:	**THERMODYNAMICS 2**
LEVEL	:	**BACHELOR**
TIME / DURATION	:	**9.00 AM – 12.00 PM (3 HOURS)**
DATE	:	**5 JANUARY 2015**

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. **Answer all questions in English.**
6. ***OPEN TEXT BOOK***

THERE ARE 6 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.

INSTRUCTION: There are NINE (9) questions. Answer FIVE (5) questions only.

(Total: 100 marks)

Please use the answer booklet provided.

Question 1

As a junior engineer, you are asked to join a team to design car engine for one company. You are required to take some measurements, prepare some designs, and do some calculations.

The thermodynamic cycle of the engine is an air-standard Otto-cycle.

The data found as listed below:

- The displacement volume of each cylinder is 1.0 L.
- The crankshaft rotates at 2600 RPM.
- The clearance volume is 15% of the volume when the piston is at the bottom dead center.
- The pressure and temperature of the gas-fuel mixture just before compression are: P = 100 kPa and T = 15 ^{o}C
- The maximum temperature the engine cylinder can tolerate is T = 1800 ^{o}C.

(i) Draw P-v and T-s Diagram. (3 marks)

(ii) Write the assumption. (2 marks)

(iii) Determine the power generated by the engine. (10 marks)

(iv) Determine the thermal efficiency of the engine. (5 marks)

Question 2

(a) The thermodynamic properties are not easy to determine because they cannot directly measured or related through some simple relation. It is essential to develop some fundamental relations between commonly encountered thermodynamic properties. The general property of entropy can be proposed as equation listed below.

$$TdS = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_p dp$$

Prove the equation. (10 marks)

(b) An engineer has proposed mixing extra oxygen with normal air in internal combustion engines to control some of the exhaust product. If an additional 5 percent (by volume) of oxygen is mixed with standard atmospheric air,

(i) Calculate the molecular weight of air standard. (3 marks)
(ii) Calculate the molecular weight of mixture's. (4 marks)
(iii) Determine the change of the mixture's molecular weight. (3 marks)

Question 3

The idea of using gas turbines to power automobiles was conceived in the 1930s, and research was done in the 1940s and 1950s by major automobile manufactures. But the cars were never mass produced because of high production cost.
A gas turbine powered Plymouth car built in 1960 had a turbine inlet temperature of 927 ^{0}C, a pressure ratio of 4, and a regenerator effectiveness of 0.9. The isentropic efficiencies for both the compressor and the turbine were 80 percent. The ambient air was at 27 ^{0}C and 100 kPa.

(i) Draw T-s diagram. (3 marks)
(ii) Write the assumption. (2 marks)
(iii) Calculate the thermal efficiency of the car. (10 marks)
(iv) Determine the mass flow rate of air for a net power output of 97 kW. (5 marks)

Question 4

Mechanical refrigeration is accomplished by continuously circulating, evaporating, and condensing a fixed supply of refrigerant in a closed system. The vapor-compression cycle is used in most household refrigerators as well as in many large commercial and industrial refrigeration systems.
The refrigerator in your kitchen uses to cool vegetables from 28 ^{0}C to 12 ^{0}C at the rate of 1140 kg/hr. The power input to the refrigerator is 8.6 kW.

Evaluate:

(i) The rate of heat absorbed from vegetables. (4 marks)
(ii) The coefficient of performance (COP). (4 marks)
(iii) The minimum power input to the refrigerator. (4 marks)
(iv) The second law efficiency of the cycle. (4 marks)
(v) The exergy destruction for the cycle. (4 marks)

Question 5

The Rankine cycle is a model that is used to predict the performance of steam engines. The Rankine cycle is an idealized thermodynamic cycle of a heat engine that converts heat into mechanical work. The heat is supplied externally to a closed loop, which usually uses water as the working fluid. The Rankine cycle closely describes the process by which steam-operated heat engines commonly found in thermal power generation plants generate power.

In a steam power plant has a mass flow rate of steam of 20,000 kg/h. Water enters the boiler (state 1) at 10 MPa and leaves the boiler (state 2) as saturated vapor. The working fluid leaves the condenser (state 4) at 10 kPa as saturated liquid. Cooling water to the condenser circulates at 1×10^6 kg/hr, and rises in temperature by 8.0°C in passing through the condenser.

(i) Draw T-s diagram. (2 marks)
(ii) Construct a state table to aid in your solution. (2 marks)
(iii) Calculate the thermal efficiency of the cycle. (10 marks)
(iv) Calculate the turbine efficiency. (3 marks)
(v) Calculate the power output of the turbine (kW). (3 marks)

Question 6

Cooling water circulated through the tubes of the condenser in a Rankine cycle must be maintained at a relatively constant inlet temperature. Where cooling water is not available from a lake, ocean, or river, cooling towers are used to remove heat from the circulating water so that the water can be recycled nearly indefinitely; some water is lost during the cooling process due to evaporation, and additional water (make-up) must be added to maintain a fixed amount of water in the system.

In a power plant, the cooling water from the condenser enters a wet cooling tower at 40 ^{0}C at a rate of 90 kg/s.

The water is cooled to 25^{0}C in the cooling tower by air that enters the tower at 1 atm, 23^{0}C, and 60 percent relative humidity and leaves saturated at 32^{0}C. Neglecting the power input to the fan,

(i) Write the assumption. (3 marks)

(ii) Evaluate the volume flow rate of air into the cooling tower. (12 marks)

(iii) Determine the mass flow rate of the required makeup water. (5 marks)

Question 7

Any material that can be burned to release thermal energy is called a fuel. Most familiar fuels consist primarily of hydrogen and carbon. They are called hydrocarbon fuels and are denoted by the general formula C_nH_m.

Assume gasoline can be treated as octane (C_8H_{18}) with a specific gravity of 0.68, and it is to be burned with air at 101.3 kPa, 27 °C.

(i) Write the assumption. (3 marks)

(ii) Determine the theoretical volume of air required to burn a liter of gasoline (in m^3). (17 marks)

Question 8 (20 marks)

Many multiphase systems encountered in practice involve two or more components.
A multicomponent multiphase system at a specified temperature and pressure is in phase equilibrium when there is no driving force between the different phases of each component.

Consider a glass of water in a room at 25°C and 100 kPa. If the relative humidity in the room is 40 percent and the water and the air are in thermal equilibrium,

(i) Write the assumption.

(3 marks)

(ii) Determine the mole fraction of the water vapor in the room air.

(8 marks)

(iii) Calculate the mole fraction of the water vapor in the air adjacent to the water surface.

(4 marks)

(iv) Determine the mole fraction of air in the water near the surface.

(5 marks)

Question 9 (20 marks)

A regenerative Brayton cycle power plant was designed and built. Before releasing the plant to the owners, the construction company had to verify the actual cycle performance. The following test data were obtained.

	Entering	Leaving
Compressor	P_1 = 97 kPa T_1 = 17 °C	P_2 = 525 kPa T_2 = 229 °C
Regenerator	P_2 = 525 kPa T_2 = 229 °C	P_3 = 510 kPa T_3 = 348 °C
Combustor	P_3 = 510 kPa T_3 = 348 °C	P_4 = 502 kPa T_4 = 727 °C
Turbine	P_4 = 502 kPa T_4 = 727 °C	P_5 = 104 kPa T_5 = 427 °C
Regenerator	P_5 = 104 kPa T_5 = 427 °C	P_6 = 97 kPa T_6 = 311 °C

The velocity at the entrance to the compressor was measured to be 135 m/sec in a pipe with a diameter of 1.6 m.

(i) Write the assumption. (2 marks)

(ii) Determine the compressor isentropic efficiency. (7 marks)

(iii) Determine the turbine isentropic efficiency. (3 marks)

(iv) Determine the regenerator effectiveness. (3 marks)

(v) Determine the net power output (in kW). (3 marks)

(vi) Calculate the cycle thermal efficiency. (2 marks)

END OF QUESTION