Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	DAK 10603
PROGRAMME	:	1 DAK
EXAMINATION DATE	:	JUNE 2015 / JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Explain briefly what is weight, force, and density and the relationship between these properties based on their SI units.

(6 marks)

(b) Construct a situation or an example to distinguish between intensive and extensive properties, and how to determine whether the property is intensive or extensive.

(6 marks)

(c) Predict the thermodynamic properties that can be measured associated with the statements below with their SI unit.

(i) Malaysia is among a county with high obesity people.

(ii) Perodua Axia boot volume size is larger than Perodua Myvi.

(iii) A balloon can explode if its pressed too hard.

(6 marks)

(d) A chemical laboratory is paying RM 0.12/kWh for its electricity rate. To reduce its electricity bill, its owner install a solar panel with a rated power of 20 kW. If the solar panel operates 2200 hours per year, determine;

(i) The yearly amount of electric power generated by the solar panel.

(ii) The money saved by the laboratory per year.

(7 marks)

Q2 (a) (i) Explain what is *pure substance*. (2 marks)

(ii) List **THREE (3)** examples of *pure substance*. (6 marks)

(b) Describe the molecular and energy changes that takes place when water, initially as an ice cube (solid), converts into liquid water and finally turned into steam (gas). (6 marks)

(c) State whether the statements below is correct or not. If the statement is not correct, suggest the correct answer.

(i) The temperature of boiling water is 100°C at 1 atm. If it is cooled at constant pressure into 80°C, it is called compressed liquid.

(ii) If water vapor is heated at constant 1 atm until its temperature exceed 200°C, this phase is called saturated liquid-vapor mixture.

(iii) Water can change phase from liquid to vapor via expansion at contant pressure of 1 atm. (6 marks)

(d) A sealed tank contain 50 kg of water at 85°C. If one third of the water is in liquid form and the rest is in vapor form, determine the volume and pressure of the tank. (5 marks)

Q3 (a) State the forms of internal energy associated with the statements below.

(i) At molecular level, electrons contain energy to rotate freely around the nucleus of an atom.

(ii) When *liquid* water is sufficiently heated until energy added to the water molecules can overcome the attractive forces between them, it will turn into *gas*.

(iii) Uncontrolled fission of uranium in atomic bomb release a huge amount of energy.

(6 marks)

(b) Write a thermodynamics situations based on each energy balance equations below:

(i) $\Delta E = \Delta PE + Q + W$.

(ii) $\Delta E = Q$.

(iii) $\Delta E = \Delta KE$.

(iv) $\Delta E = \Delta U + Q$.

(8 marks)

(c) (i) An engineer increase a water pump pressure from 15 psia to 70 psia. The outlet pipe of this water pump is directly connected into a storage tank located 10 meter higher. Determine the power input required (in hp) to pump 0.02 m^3/s of water taking into account that water density is 1000 kg/m^3.

(6 marks)

(ii) Water is being heated in a closed pan while being stirred by a paddle wheel. During the heating process, 40 kJ of heat is transferred to the water, while 6 kJ of heat is lost to the surrounding air. The paddle-wheel does 500 N.m work to the water. Write the energy balance equation thus determine the final energy of the system, given that its initial energy is 10 kJ.

(5 marks)

Q4 (a) (i) State all variable and constant parameters for isothermal, isobaric and polytropic process.
(6 marks)

(ii) Explain why the boundary work, W_b for constant-volume process, in piston cylinder device is always zero.
(2 marks)

(iii) Prove that 1 kPa.m^3 = 1 kJ.
(2 marks)

(b) Write a the general energy balance equations (for closed system) based on thermodynamic situations below.

(i) A piston-cylinder device containing 10 kg of saturated vapor is compressed isothermally into saturated liquid.

(ii) A piston-cylinder device containing liquid Nitrogen gas is heated at constant volume.
(4 marks)

(c) (i) A piston-cylinder device initially contain 0.07 m^3 of nitrogen gas (N_2) at 130 kPa and 120°C. The nitrogen is now expanded poytropically to a state of 100 kPa and 100°C. Determine the boundary work, W_b for this process.
(5 marks)

(ii) A student living in a fixed 4 m × 6 m × 6m room, turned on her 150 Watt fan before she leaves her room on a hot morning, hoping that her room will be cooler when she retuned back in the evening. Assuming all the doors and windows are tightly closed and neglecting heat transfer from the room to its surrounding, determine the temperature of the room when she comes back 8 hours later. Use specific heat values at room temperatures, given that the room is at 100 kPa and 28°C in the morning when she leaves.
(6 marks)

Q5 (a) (i) State **THREE (3)** characteristics of a steady flow system that can be found in a nozzle attached to a garden hose.

(6 marks)

(ii) List **FOUR (4)** of engineering devices utilizing steady flow system.

(4 marks)

(b) Outline the differences between turbines and compressors.

(4 marks)

(c) Air enters a nozzle steadily at 2.21 kg/m^3 and 40 m/s and leaves at 0.762 kg/m^3 and 180 m/s. If the inlet area of the nozzle is 60 cm^2, determine the exit diameter of the nozzle, in cm.

(4 marks)

(d) Air at 17 °C and 80 kPa enters the diffuser of a jet steadily with a velocity of 200 m/s. The inlet area of the diffuser is 0.4 m^2. The air leaves the diffuser with a velocity that is very small (almost zero) compared to the inlet velocity. Determine:

(i) The mass flow rate of the air.

(3 marks)

(ii) The temperature of air leaving the diffuser.

(4 marks)

Q6 (a) (i) Define thermal reservoir and heat engines.

(4 marks)

(ii) Explain why does a heat engine such as steam power plant operates in a cycle but a car engine (which is also a heat engine) is not.

(4 marks)

(iii) Heat is transferred to a heat engine from a furnace at a rate of 80 MW. If the rate of waste heat rejection to a nearby river is 60 MW, determine the net power output and the thermal efficiency of this heat engine.

(4 marks)

(b) List out **FIVE (5)** conclusions of the equilibrium constant, K_p for ideal-gas mixtures.

(5 marks)

(c) Based on the Gibbs function data and the calculated equilibrium constant, K_p for the dissociation process of oxygen (O_2), prove why the preferred operating temperature for this process is 3727 °C, not 25 °C.

Table **Q6 (c)**: Gibbs function data

Process: $O_2 \leftrightarrow 2O$	
Temperature (K)	$\Delta G^{*}(T)(kJ/kmol)$
298K	-186.975
4000K	0.796

(8 marks)

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Formulas

Watt = Joule / second

1 year = 365 days

$Q + W = \Delta U + \Delta KE + \Delta PE$ (closed system)

$(Q + W)_{in} - (Q + W)_{out} = (U + KE + PE)_{final} - (U + KE + PE)_{initial}$ (closed system)

$x = m_{vapor} \div m_{total}$

$v_{avg} = (1 - x)\, v_f + x\, v_g$ (kg/m^3)

$$\dot{E}_{mech}\left(\frac{J}{s}\right) = \dot{m}\left(\frac{P_2 - P_1}{\rho} + \frac{{v_2}^2 - {v_1}^2}{2} + g(z_2 - z_1)\right)$$

$$W_b(Joule) = \int P \times dV$$

$$W_b = \int P \times dV = \frac{P_2V_2 - P_1V_1}{1 - n} = \frac{NR(T_2 - T_1)}{1 - n} \quad (piston\ cylinder, polytropic)$$

$$n = \left(log\frac{P_2}{P_1}\right) \div \left(log\frac{V_1}{V_2}\right)$$

$$N = \frac{PV}{RT} \quad , R = 8.314\frac{J}{mol.K} = 8.314\frac{Pa.m^3}{mol.K}$$

$$Q + W = \Delta U \quad (ideal\ gas, rigid\ volume)$$

$$\Delta U = m \times C_v \times (T_2 - T_1) \quad (ideal\ gas, rigid\ volume)$$

$$m(g) = N\ (mol) \times JAR\ \left(\frac{g}{mol}\right)$$

$$JAR_{air} = 29\frac{g}{mol}$$

$$C_v\ for\ air = 0.718\frac{kJ}{kg.K}$$

$$T(K) = T(°C) + 273$$

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

$$ln\ K_p = \Delta G^*(T) \div (R \times T)$$

$$\eta = \frac{Power\ used\ (actual)}{Power(supplied)}$$