Menoufia University
Faculty of Engineering
Mech. Power Dept.
Shebin El-Kom, Egypt.
2^{nd} Semester Examination 2017-2018

جامعة المنوفية

Subject: Thermodynamics (MPE 128)
Level : 1^{st} year (electrical)
Time Allowed: 3 hours
Total Marks : 70 marks
Date of Exam : 30/5/2018

ملحوظة : من فضلك لا تستخدم القلم الرصاص فى الاجابة

Notes: 1- The exam consists of 6 questions distributed over two pages
2- The universal gas constant= 8314 J/kmol-K

Question # 1 (10 marks)

a) What is meant by: extensive system property - system internal energy (2 marks)

b) Define the enthalpy of a thermodynamics system and show that the enthalpy of an ideal gas depends only on the gas temperature. (2 marks)

c) Helium gas (M=4, $\gamma = 1.667$) at 450 kPa, 57 °C is contained in 1.5 m^3 rigid tank. The gas leaked out the tank through a valve till the pressure and temerature of the gas reached 200 kPa and 37 °C at which point the valve is closed.

a. Calculate the helium gas constant R (1 mark)
b. What is the mass of the helium gas leaked out the tank ? (2 marks)
c. If the helium gas eventually cools to 27 °C. Find the final gas pressure inside the tank and the amount of heat rejected during the cooling process (in kWh). (3 marks)

Question # 2 (14 marks)

a) One kg of an ideal gas undergoes a process between state 1 and state 2. During the process the absolute gas temperature is varied with the gas volume as $T\,V = const.$ Derive an expression for the boundary work during the process and prove that the heat transfer during the process can be expressed as: $Q_{12} = (2\,C_V - C_P)(T_2 - T_1)$; where C_V, C_P are the gas specific heats at constant volume and constant pressure, respectively. (4 marks)

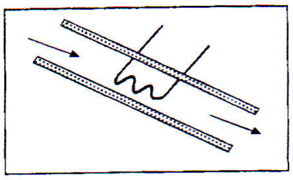
b) 1.5 kg of air (R=287 J/kg-k, γ=1.4) at pressure of 3 bar and a volume of 0.45 m^3 expands to a pressure of 1 bar following the relation PV=const. Sketch the process on P-V and T-v diagrams and Determine 1- the final air temperature 2- the work done during the process 3- the change in air enthalpy 4- the heat transfer during the process. (5 marks)

c) 1.25 kg of a gas undergoes an equilibrium constant pressure process during which the gas specific volume decreases by 0.16 m^3/kg and the specific net energy transfer across the system (gas) boundary is (+72) kJ/kg. The boundary work is the only work transfer during the process and is equal to (- 24) kJ. Sketch the process on P-V diagram and (1 mark)
- Determine the gas pressure during the process (in Pa) (2 marks)
- Calculate the change of gas energy and the heat transfer during the process (2 marks)

Question # 3 (11 marks)

a) Write down the first law of thermodynamics for SSSF process and explain briefly the meaning of every term in the law. (2 marks)

b) Liquid water with specific volume of 0.0015 m^3/kg and specific enthalpy of 125 kJ/kg enters an insulated tube with mass flow rate of 0.1 kg/s. The water is heated through a resistor inserted in the tube. The water exits the tube with specific enthalpy of 145 kJ/kg. Determine the volume flow rate of water at the tube inlet and the rate of electrical work input to the resistor if the tube exit is 5 m lower than the tube inlet. (4 marks)



c) Hot air (R=287 J/kg-k, γ=1.4) enters a convergent nozzle at pressure of 305 kPa and temeprature of 400 K and with velocity of 18 km/hr. The air exits the nozzle at 100 kPa, 360 K. During air flow in the nozzle, the nozzle surface dissipates 7200 kJ of heat to the surroundings every hour. If the nozzle inlet diameter is 12 cm, determine the air exit velocity and the nozzle exit diameter (in cm). (5 marks)

→ This is the first page please see the second page →

[NB Please don't use Pencil in your solution,
For air C_v= 718 kJ/kg, R = 287 J/kg K]

Question # 4 (9 marks)

a) A refrigerator uses 100 J of work to remove 200 J of heat from its contents. Calculate, (3 marks)

i. the coefficient of performance.
ii. the heat rejected to the surroundings.

b) An engine that has an efficiency of 25% takes in 200 J of heat during each cycle. (3 marks)
Calculate,

i. the work this engine performs.
ii. the heat must it reject to the heat sink.

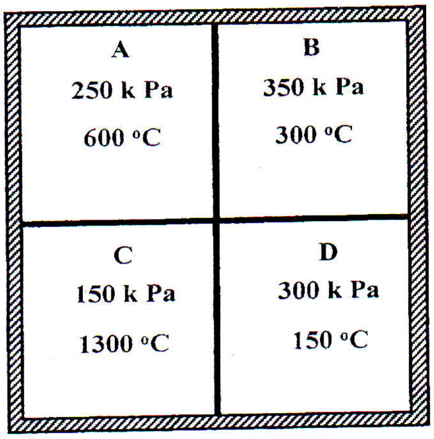
c) A Carnot heat pump with heating capacity of 10 kW used to heat a house to keep it's inside temperature at 25 °C while atmospheric temperature is (-15 °C). Calculate, (3 marks)

i. the power required to drive the heat pump.
ii. the heat it picks up from the atmosphere.

Question # 5 (12 marks)

An adiabatic thermodynamic system composes of four thermal insulated compartments with equal volumes of 0.1 m^3 as shown in figure. The compartments contain air with pressure and temperature as given. If the insulation between the compartments is removed while they remain unmixed and left to attain thermal equilibrium calculate,

i- the final temperature of the whole system and the final pressure in each compartment.
ii- the entropy change for each compartment.
iii- the loss in available energy due to this process.



Question # 6 (14 marks)

An Otto cycle has a compression ratio of 10/1. If heat input is 300 kJ/kg and pressure and temperature at compression start are 100 kPa and 27°C respectively. Calculate,

i. the thermal efficiency.
ii. the maximum cycle temperature and pressure.
iii. the network output per kg of air.

With our best wishes

End of questions

This exam measures the following ILOs												
Question Number	Q1-(a,b,c)	Q2-(a,b,c)	Q3-a	Q4-(a,b,c)	Q6	Q2-(a,b,c)	Q3-(b,c)	Q4-(a,b,c)	Q5	Q6	Q2	Q5
Skills	A5-2	A5-6	A5-7	a5-9	a5-13	b2-4	b2-6	b2-11	b2-9	b2-12	C1-1	c1-3
	Knowledge &Understanding Skills					Intellectual Skills					Professional Skills	