Kafrelsheikh University		**Semester: ٢nd Semester**
Mechanical Engineering		**Final Examination**
Dept. Mechanical Engineering		**Date: May 23th, 2019**
Year: Fist Year		**Time allowed: 3 hour**
Instructor: Assoc. Prof. Maher		**Full Mark: 60**
Subject: Thermodynamics I (MEP1203)		
Questions and Answers Booklet		

(a) This exam measures ILOs no.: a.5 b.2 c.1 d7, and d9
(b) No. of questions: 5. No. of pages: 11 (only pages no [7/11], [8/11], and [11/11] are empty)
(c) This is a close book exam. Only thermodynamics tables and calculator are permitted
(d) Clear, systematic answers and solutions are required. In general, marks will not be assigned for answers and solutions that require unreasonable (in the opinion of the instructor) effort to decipher.
(e) Retain all the significant figures of properties taken from tables. Final results should have at least 3 to 5 significant digits.
(f) Ask for clarification if any question statement is not clear to you.
(g) Solve all questions.
(h) The exam will be marked out of 60. There are 23 marks bonus.

Question #1 (30 Marks)

Choose the correct answer. Justify your answer with calculations or explanations or both whenever possible. If answer requires justification, marks will not be given to the correct answer without justification.

1. The latent heat of vaporization at critical point is **(0.5 Mark)**
   (*a*) less than zero (*b*) greater than zero
   (*c*) equal to zero (*d*) none of the above.

2. Select a correct statement of the first law if kinetic and potential energy changes are neglected. **(1 Marks)**
   (A) Heat transfer equals the work done for a process.
   (B) Net heat transfer equals the net work for a cycle.
   (C) Net heat transfer minus net work equals internal energy change for a cycle.
   (D) Heat transfer minus work equals internal energy for a process.

3. A definite area or space where some thermodynamic processes takes place is known as **(0.5 Mark)**
   (a) thermodynamic system (b) thermodynamic cycle
   (c) thermodynamic process (d) thermodynamic law.

4. An open system is one in which **(1Mark)**
   (a) heat and work cross the boundary of the system, but the mass of the working substance does not
   (b) mass of working substance crosses the boundary of the system but the heat and work do not

(c) both the heat and work as well as mass of the working substances cross the boundary of the system
(d) neither the heat and work nor the mass of the working substances cross the boundary of the system.

5. An isolated system **(0.5 Mark)**
(a) is a specified region where transfer of energy and/or mass take place
(b) is a region of constant mass and only energy is allowed to cross the boundaries
(c) cannot transfer either energy or mass to or from the surroundings
(d) is one in which mass within the system is not necessarily constant

6. Which of the following is an intensive property of a thermodynamic system ? **(0.5 Mark)**
(a) Volume (b) Temperature
(c) Mass (d) Energy.

7. Which of the following is the extensive property of a thermodynamic system ? **(0.5 Mark)**
(a) Pressure (b) Volume
(c) Temperature (d) Density.

8. When two bodies are in thermal equilibrium with a third body they are also in thermal equilibrium witheach other. This statement is called **(0.5 Marks)**
(a) Zeroth law of thermodyamics (b) First law of thermodynamics
(c) Second law of thermodynamics (d) Kelvin Planck's law.

9. Select a correct statement of the first law if kinetic and potential energy changes are neglected. **(1 Marks)**
(A) Heat transfer equals the work done for a process.
(B) Net heat transfer equals the net work for a cycle.
(C) Net heat transfer minus net work equals internal energy change for a cycle.
(D) Heat transfer minus work equals internal energy for a process.

10. Absolute zero temperature is taken as **(0.5 Mark)**
(a) – 273°C
(b) 273°C
(c) 237°C
(d) – 373°C.

11. Which of the following is correct ? **(0.5 Mark)**
(a) Absolute pressure = gauge pressure + atmospheric pressure
(b) Gauge pressure = absolute pressure + atmospheric pressure
(c) Atmospheric pressure = absolute pressure + gauge pressure
(d) Absolute pressure = gauge pressure – atmospheric pressure

12. The point that connects the saturated-liquid line to the saturated-vapor line is called the **(0.5 Marks)**
(A) triple point
(B) critical point
(C) superheated point
(D) compressed liquid point

13. Propane (C_3H_8) is an ideal gas is maintained at 6.39 MPa and 444 K. How much volume does 1 kg of this gas fill? **(1 Marks)**

(a) 8.78 liters (b) 12.3 liters
(c) 13.1 liters (d) 15.7 liters

$pv = mRT \qquad V = mRT/p = 1\times(8.314/44)\times 444/6390 = 0.0131\,\text{m}^3 = 13.1\,\text{litre}$

14. For each of the cases below, determine if the heat engine satisfies the first law (energy equation) and if it violates the second law. **(2 Marks)**

a. $\dot{Q}_H = 8$ kW $\quad \dot{Q}_L = 0$ kW $\quad \dot{W} = 8$ kW
b. $\dot{Q}_H = 8$ kW $\quad \dot{Q}_L = 4$ kW $\quad \dot{W} = 4$ kW
c. $\dot{Q}_H = 8$ kW $\quad \dot{Q}_L = 8$ kW $\quad \dot{W} = 0$ kW
d. $\dot{Q}_H = 8$ kW $\quad \dot{Q}_L = 5$ kW $\quad \dot{W} = 3$ kW

	1st Law	2nd Law
a.		
b.		
c.		
d.		

15. An apple with an average mass of 0.18 kg and average specific heat of 3.65 kJ/kg·°C is cooled from 22°C to 5°C. The amount of heat transferred from the apple is **(1 Mark)**

(a) 0.85 kJ
(b) 62.1 kJ
(c) 17.7 kJ
(d) 11.2 kJ
(e) 7.1 kJ

16. The specific heat at constant volume for an ideal gas is given by $c_v = 0.7 + (2.7\times10^{-4})T$ (kJ/kg·K) where T is in kelvin. The change in the internal energy for this ideal gas undergoing a process in which the temperature changes from 27 to 127°C is most nearly **(1 Mark)**

(a) 70 kJ/kg
(b) 72.1 kJ/kg
(c) 79.5 kJ/kg
(d) 82.1 kJ/kg
(e) 84.0 kJ/kg

17. An ideal gas has a gas constant R = 0.3 kJ/kg·K and a constant-volume specific heat c_v = 0.7 kJ/kg·K. If the gas has a temperature change of 100°C, choose the correct answer for each of the following: **(2.5 Marks)**

1. The change in enthalpy is, in kJ/kg
(a) 30 (b) 70 (c) 100
(d) insufficient information to determine

2. The change in internal energy is, in kJ/kg
(a) 30 (b) 70 (c) 100
(d) insufficient information to determine

3. The work done is, in kJ/kg
(a) 30 (b) 70 (c) 100
(d) insufficient information to determine

4. The heat transfer is, in kJ/kg

(a) 30 (b) 70 (c) 100
(d) insufficient information to determine

5. The change in the pressure-volume product is, in kJ/kg
(a) 30 (b) 70 (c) 100
(d) insufficient information to determine

18. An ideal gas undergoes a constant temperature (isothermal) process in a closed system. The heat transfer and work are, respectively **(1 Mark)**

(a) 0, $-c_v\Delta T$ (b) $c_v\Delta T$, 0 (c) $c_p\Delta T$, $R\Delta T$
(d) $RT\ln(P_1/P_2)$, $RT\ln(P_1/P_2)$

19. An ideal gas undergoes a constant volume (isochoric) process in a closed system. The heat transfer and work are, respectively **(1 Mark)**

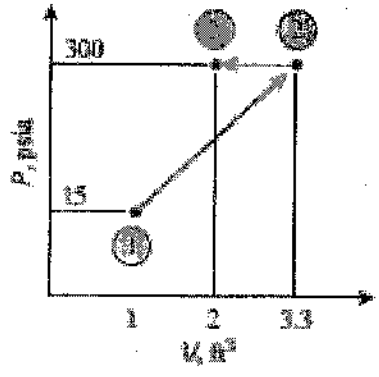
(a) 0, $-c_v\,\Delta T$ (b) $c_v\,\Delta T$, 0 (c) $c_p\,\Delta T$, $R\Delta T$
(d) $R\ln(T_2/T_1)$, $R\ln(T_2/T_1)$

20. An ideal gas undergoes a constant pressure (isobaric) process in a closed system. The heat transfer and work are, respectively **(1 Mark)**

(a) 0, $-c_v\,\Delta T$ (b) $c_v\,\Delta T$, 0 (c) $c_p\,\Delta T$, $R\Delta T$
(d) $R\ln(T_2/T_1)$, $RT\ln(T_2/T_1)$

21. The total work, in J , for process 1–3 shown below **(3 Marks)**

(a) -54 J (b) 54 J
(c) -108 J (d) 108 J



22. A heat pump is absorbing heat from the cold outdoors at 5 °C and supplying heat to a house at 25°C at a rate of 18,000 kJ/h. If the power consumed by the heat pump is 1.9 kW, the coefficient of performance of the heat pump is **(1 Marks)**

(*a*) 1.3
(*b*) 2.6
(*c*) 3.0
(*d*) 3.8
(*e*) 13.9

23. A heat engine cycle is executed with steam in the saturation dome. The pressure of steam is 1 MPa during heat addition and 0.4 MPa during heat rejection. The highest possible efficiency of this heat engine is **(2 Marks)**

(*a*) 8.0%
(*b*) 15.6%
(*c*) 20.2%
(*d*) 79.8%
(*e*) 100%

24. A heat engine receives heat from a source at 1000°C and rejects the waste heat to a sink at 50°C. If heat is supplied to this engine at a rate of 100 kJ/s, the maximum power this heat engine can produce is **(2 Marks)**

(*a*) 25.4 kW
(*b*) 55.4 kW
(*c*) 74.6 kW
(*d*) 95.0 kW
(*e*) 100 kW

25. Air at 27°C and 5 atm is throttled by a valve to 1 atm. If the valve is adiabatic and the change in kinetic energy is negligible, the exit temperature of air will be **(1 Mark)**

(a) 10°C
(b) 15°C
(c) 20°C
(d) 23°C
(e) 27°C

26. Steam at 1 MPa and 300°C is throttled adiabatically to a pressure of 0.4 MPa. If the change in kinetic energy is negligible, the specific volume of the steam after throttling is **(2 Marks)**

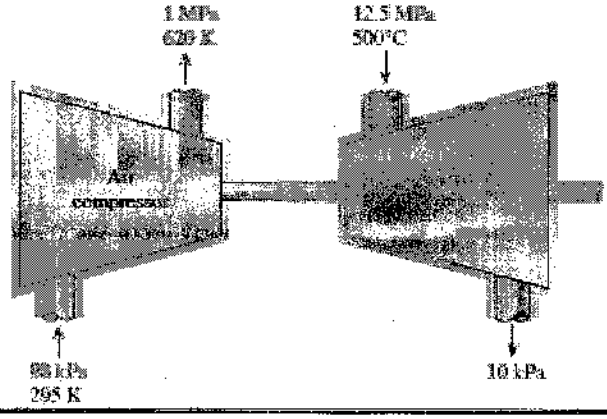
(a) 0.358 m^3/kg
(b) 0.233 m^3/kg
(c) 0.375 m^3/kg
(d) 0.646 m^3/kg
(e) 0.655 m^3/kg

27. Air is to be heated steadily by an 8-kW electric resistance heater as it flows through an insulated duct. If the air enters at 50°C at a rate of 2 kg/s, the exit temperature of air is **(1 Marks)**

(a) 46.0°C
(b) 50.0°C
(c) 54.0°C
(d) 55.4°C
(e) 58.0°C

Question #2 (10 Marks)

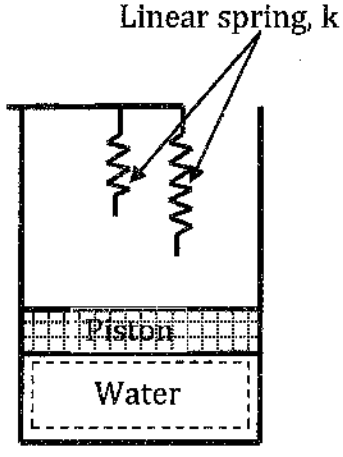
An adiabatic air compressor is to be powered by a direct-coupled adiabatic steam turbine that is also driving a generator. Steam enters the turbine at 12.5 MPa and 500°C at a rate of 25 kg/s and exits at 10 kPa and a quality of 0.92. Air enters the compressor at 98 kPa and 295 K at a rate of 10 kg/s and exits at 1 MPa and 620 K. Determine the net power delivered to the generator by the turbine.



Solution

Question #3 (22 Marks)

Two identical linear springs with spring constants (K) are installed in a piton/cylinder arrangement with outside air at 100 kPa. The cylinder (shown in the Figure) contains 1 kg of water initially at 110 °C and a quality of 15% (state 1). Heat is added to the cylinder until the pressure and temperature inside the cylinder are 1 MPa and 1300 C (state 4), respectively. If the piston comes in contact with the first spring with a constant of *K* when the volume of the cylinder equals =0.25 m^3 (state 2) and with the second spring of a constant of 2K when the volume of the cylinder is doubled (state 3). Calculate

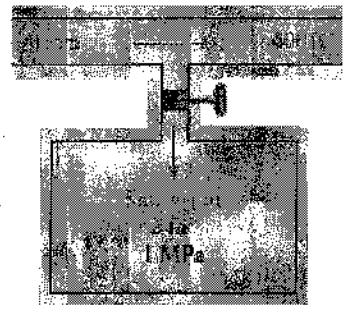


a. Mass of piston if its cross sectional area is 500 cm^2. **(3 Marks)**
b. Springs constant. **(7 Marks)**
c. Pressure at which piston comes in contact with the second spring, P_3. **(1 Marks)**
d. Work done by water in each process and net work. **(4 Marks)**
e. Heat transfer to the cylinder. **(3 Marks)**
f. Draw a *P-V* diagram showing the state points and process path(s). label the values of P and V for each state point and clarify label the constant temperature lines that passes through the state points. **(4 Marks)**

Solution

Question #4 (10 Marks)

A 2-m^3 rigid insulated tank initially containing saturated water vapor at 1 MPa is connected through a valve to a supply line that carries steam at 400°C. Now the valve is opened, and steam is allowed to flow slowly into the tank until the pressure in the tank rises to 2 MPa. At this instant the tank temperature is measured to be 300°C. Determine the mass of the steam that has entered and the pressure of the steam in the supply line.



Solution

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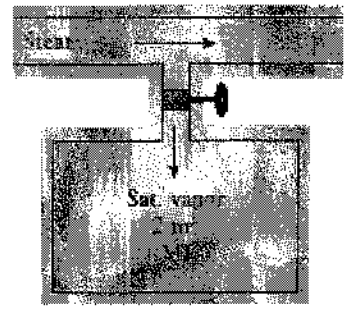

Solution