Indian Maritime University

(A Central University, Govt of India)

End Semester Examinations – December 2022

Programme Name: B Tech (ME)

Semester: II

Subject Code: UG11T4205

Subject Name: Basic Thermodynamics

Date: 01.12.2022	Max Marks: 70
Duration: 03 Hrs	Pass Marks: 35

General Instructions

(i) All Sections (A, B & C) are to be attempted.
(ii) Options, if any, are specified in respective section.

(iii) Steam tables can be used for finding the corresponding values.

Section A

Ten MCQs/Fill in the Blanks of 01 Mark each – Choose the correct answer as applicable.

1. If temperature of the source is increased, the efficiency of Carnot Engine
   a. Decreases
   b. Increases
   c. Remains Constant
   d. First increase and then becomes constant

2. The measure of the degree of disorder/randomness of a system is known as
   a. Enthalpy
   b. Isochoric process
   c. Isobaric process
   d. Entropy

3. Reversible adiabatic flow is
   a. Ideal fluid flow
   b. Irreversible adiabatic flow
   c. Isentropic Flow
   d. Frictionless reversible flow

4. Which among the following is an extensive property?
   a. Temperature

b. Specific Enthalpy
c. Pressure
d. Entropy

5. For a given temperature T_1 and T_2, as the difference T_1 and T_2 increases, the COP of a Carnot Heat Pump

a. Increases
b. Decreases
c. Does not change
d. First increases, then decreases

6. The value of $\oint dQ/T$ for an reversible cycle is

a. Equal to zero
b. Greater than zero
c. Less than zero
d. Unity

7. There is no work transfer involved in this process

a. Adiabatic Expansion
b. Isothermal Expansion
c. Polytropic Expansion
d. Free Expansion

8. Concept of Heat Pump comes from which law of thermodynamics?

a. Zeroth Law of Thermodynamics
b. First Law of Thermodynamics
c. Second Law of Thermodynamics
d. Third Law of Thermodynamics

9. Increase in entropy of a system represents

a. Increase in availability of energy
b. Decrease in pressure
c. Degradation of energy
d. Increase in temperature

10. If there is transfer of heat or shaft work during the flow-through confined passage problem; which equation will be applicable for such problems?

e. Bernoulli's Equation
f. Steady Flow Energy Equation
g. Euler's Equation
h. Laplace Equation

Section B

Five Questions of 02 Marks each

11. Explain the difference between Heat Engine and Heat Pump?

12. What is the difference between Critical Point and Triple Point?

13. Why the second law is called as law of degradation of energy?

14. What is Dryness Fraction? Does it have any meaning in the superheated vapour region?

15. Define the specific heats at Constant Pressure and Constant Volume?

Section C

Seven Questions of 10 Marks each of which any 05 questions to be answered.

16. Explain an adiabatic process? Derive the equation for pdV-Work in adiabatic process?

(3+7 Marks)

17. A) Prove that energy is a property
B) Steam at 3 MPa and 400°C enters an adiabatic nozzle steadily with a velocity of 45 m/s and leaves at 2.5 MPa and 270 m/s. Determine the enthalpy of the steam at the exit.

(5+5 Marks)

18. Two Carnot Engines A and B are connected in series between two thermal reservoirs. Engine A receives 1600 kJ of heat from the high temperature reservoir maintained at 1200 K and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and rejects heat to the low temperature reservoir maintained at 200 K. If engines A and B have equal thermal efficiencies, determine
    a. the heat rejected by engine B
    b. temperature at which heat is rejected by engine A
    c. calculate the work done by engine A and B.

(10 Marks)

19.
    a. A mass of 10 kg gas expands within a flexible container so that the p–v relationship is of the from $pv^{1.2}$ = constant. The initial pressure is 800 kPa and the initial volume is 1.2 m^3. The final pressure is 10 kPa. If specific internal energy of the gas decreases by 50 kJ/kg, find the
        i. magnitude and direction of work done.
        ii. change in internal energy.
        iii. magnitude and direction of heat transfer. (7 Marks)

    b. A refrigeration plant for a food store operates as a reversed Carnot heat engine cycle. The store is to be maintained at a temperature of 268 K. If heat is transferred from the cycle to the atmosphere at a temperature of 298 K, calculate the COP of the plant.

(3 Marks)

20. An iron block of unknown mass at 90°C is dropped into an insulated tank that contains 0.2 m^3 of water at 20 °C. At the same time, a paddle wheel driven by a 250 W motor is activated to stir the water. Thermal equilibrium is establishes after 20 min when the final temperature is 28 °C. Determine the mass of the iron block and the exergy destroyed during the process.

Take: Density and specific heat of water = 1000 kg/m^3 and c_p = 4.18 kJ/kg.K. The specific heat of iron at room temperature is c_p = 0.45 kJ/kg.K

(5+5 Marks)

21. A vessel of volume 0.03 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250°C. The mass of the liquid present is 10 kg. Calculate the mass, the specific volume, the enthalpy, the entropy, and the internal energy.

At 250 °C, take

$p_{sat} = 3.973\text{MPa}$

$v_f = 0.0012512\ \text{m}^3/\text{kg},\ v_g = 0.05013\ \text{m}^3/\text{kg}$

$h_f = 1085.36\ \text{kJ/kg},\ h_{fg} = 1716.2\ \text{kJ/kg}$

$s_f = 2.7927\ \text{kJ/kgK},\ s_{fg} = 3.2802\ \text{kJ/kgK}$

(10 Marks)

22. A piston-cylinder device contains 0.18 kg of steam at 1.4 MPa and 290°C. Steam then expands to a final state of 220 kPa and 150°C, doing boundary work. Heat losses from the system to the surroundings are estimated to be 5 kJ during this process. Assume the surroundings to be at 25°C and 100 kPa, determine the exergy change ($\Delta\Phi$) of steam

(10 Marks)