Code : 021407

2013

THERMODYNAMICS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct answer (any *seven*) : 2×7=14

(a) In case of free expansion between state-1 and state-2, which of the following is correct considering no heat interaction?

(i) $U_1 = U_2$

(ii) $W_{1-2} = 0$

(iii) $Q_{1-2} = 0$

(iv) All of the above

(b) The latent heat of vaporisation with increase in pressure of water

(i) increases

(ii) remains constant

(iii) decreases

(iv) None of the above

(c) As differentials heat and work would be described mathematically as

(i) inexact

(ii) exact

(iii) discontinuity

(iv) point function

(d) Heat is being supplied to air in a cylinder fitted with a frictionless piston held by a constant weight, the process is

(i) isochoric

(ii) isobaric

(iii) adiabatic

(iv) isothermal

(e) Expansion of hot gases in an IC engine can be approximated to an

(i) isochoric

(ii) isobaric

(iii) adiabatic

(iv) isothermal

(f) A refrigerator and a heat pump operate between same temperature limits. If the COP of refrigerator is 4, then the COP of heat pump is

(i) 3

(ii) 4

(iii) 4·4

(iv) 5

(g) A relation of vapour pressure to enthalpy of vaporisation is expressed in

(i) van der Waals equation

(ii) Maxwell relation

(iii) Carrier equation

(iv) Clausius-Clapeyron equation

(h) For same maximum pressure and temperature among Otto, diesel and dual cycles

(i) diesel cycle is most efficient

(ii) Otto cycle is most efficient

(iii) dual cycle is most efficient

(iv) None of the above

(i) Thermal efficiency of Rankine cycle can be improved by steam

(i) reheating

(ii) superheating

(iii) regeneration

(iv) None of the above

(j) The process of removing moisture from air at constant dry-bulb temperature is known as

(i) sensible heating

(ii) sensible cooling

(iii) dehumidification

(iv) humidification

2. (a) Define internal energy. Show that internal energy is a property of a system. 6

(b) A cylinder contains $0 \cdot 12\ m^3$ of air at 1 bar and 90 °C. It is compressed to $0 \cdot 03\ m^3$. The final pressure being 6 bar. Find the index of compression, increase in internal energy and heat transferred. Take $R = 0 \cdot 287$ kJ/kg-K and $C_v = 0 \cdot 717$ kJ/kg-K. 8

3. (a) Prove that the Kelvin-Planck and Clausius statement of the second law of thermodynamics are equivalent to each other. 6

(b) A reversed Carnot cycle operating as a refrigerator has a refrigerating capacity of 100 kJ/s while operating between temperature limits of −20 °C and 35 °C. Determine (i) power input and (ii) COP. What would be its efficiency if it runs as an engine? 8

4. (a) State and prove Clausius inequality. 7

(b) During isothermal heat addition process of a Carnot cycle, 800 kJ heat is added to the working fluid from a source of 527 °C. Determine (i) change in entropy of the working fluid, (ii) change in entropy of the source and (iii) total entropy change during the process. 7

(Continued)

5. *(a)* Define the following : 6

(i) Pure substance

(ii) Saturation state

(iii) Triple point and critical point

(b) A vessel of volume 0·04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250 °C. The mass of liquid is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and the internal energy. 8

6. In an air-standard dual cycle, the pressure and temperature at beginning of compression are 1 bar and 57 °C respectively. The heat supplied in the cycle is 1250 kJ/kg, two-third of this being added at constant volume and rest at constant pressure. If the compression ratio is 16, determine the air-standard efficiency. 14

7. *(a)* Give limitation of Carnot vapour power cycle and explain how Rankine cycle helps in overcoming them. 5

(b) A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 500 °C and leaving LP turbine at 90% dryness. Considering condenser pressure of 0·005 MPa and reheating occurring up to the temperature of 500 °C, determine the thermal efficiency of the cycle. 9

8. *(a)* What do you understand by dry-bulb and wet-bulb temperatures? When do d.b.t., w.b.t. and d.p.t. become equal? 6

(b) 10 m^3/min of air at 1 atm and 20 °C with 90% RH is mixed with 20 m^3/min of air at 1 atm and 40 °C with 20% RH. Calculate the resulting state of mixture. 8

9. *(a)* Explain Maxwell relation in thermodynamics. 6

(b) A gaseous mixture consists of 1 kg of oxygen and 2 kg of nitrogen at a pressure of 150 kPa and a temperature of 20 °C. Determine the change in internal energy and enthalpy of the mixture when the mixture is heated to a temperature of 100 °C *(i)* at constant volume and *(ii)* at constant pressure. 8

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