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ME 181303

Roll No. of candidate | | | | | | | | | | |

25/2/22 2021

B.Tech 3rd Semester End-Term Examination

ME, IPE

BASIC THERMODYNAMICS

(New Regulation & New Syllabus)

Full Marks – 70 Time – Three hours

The figures in the margin indicate full marks for the questions.

Stream table is allowed

Answer question Nos. 1 & 2 and any five from the rest

1. Choose the correct answer $(10 \times 1 = 10)$

(i) The minimum amount of oxygen required for the combustion of 0.3 kg of carbon

(a) 0.8 kg

(b) 0.7 kg

(c) 1.2 kg

(d) 1.0 kg

(ii) The compression ratio of an I.C engine is the ratio of

(a) Swept volume to clearance volume

(b) Total cylinder volume to clearance volume

(c) Total cylinder volume to swept volume

(d) Pressure after compression to that before compression

(iii) The internal energy of perfect gas does not change during

(a) Adiabatic process

(b) Isobaric process

(c) Isothermal process

(d) Isochoric process

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(iv) For a fixed quantity of heat added to a system under specific conditions, the entropy change will be maximum in the case of

(a) Isentropic process

(b) Isobaric process

(c) Isothermal process

(d) Isochoric process

(v) For any natural process, the entropy change would be

(a) Zero

(b) Positive

(c) Negative

(d) Unpredictable; insufficient data

(vi) The enthalpy of evaporation is minimum at

(a) Absolute zero

(b) 374°K

(c) Critical point

(d) Triple point

(vii) During formation of steam at atmospheric pressure, the temperature was noted be 120°C. It suggests that the steam is

(a) Wet steam

(b) Dry steam

(c) Superheated steam

(d) Unpredictable

(viii) The expression $\int_1^2 pdV$ gives the measure of work done for

(a) Non-flow reversible work

(b) Steady flow reversible work

(c) Open system and any process

(d) Any system and any process

(ix) Heat supplied to a system equals the work done in case of a non-flow process carried out

(a) Iso-chorically

(b) Iso-barically

(c) Isothermally

(d) Adiabatically

(x) In an insulated rigid vessel contains some gas and an electric heater. In certain interval of time, the resistance connected to an external electrical power heats the gas. Considering the vessel and its content as the system

(a) Heat and work transfer zero

(b) Heat and work transfer are positive

(c) Heat transfer is zero and the work transfer is negative

(d) Heat transfer is positive and the work transfer is zero

2. Explain *any four* $(4 \times 2.5 = 10)$

(a) $\oint dQ \neq 0$ but $\oint dT = 0$

(b) Thermal efficiency of a heat engine cannot be 100%

(c) Too much excess air or too low air in combustion is not desirable.

(d) The entropy of universe cannot decrease.

(e) The thermal efficiency of two-stroke engine is lower than that of the four-stroke engine

(f) Engineers are interested for the reversible process.

3. (a) Prove that energy is a property of a system. (3)

(b) Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m3/kg and leaving at 5 m/s with a pressure of 7 bar and a specific volume of 0.16 m^3/kg. The internal energy of air leaving the compressor is 90 kJ/kg greater than that of the air entering. The compressor is cooled with water and the amount of heat absorbed by the water from the surface of the compressor is 60 W. (7)

(i) Calculate the power required to drive the compressor and

(ii) The cross-sectional area of the inlet and the outlet.

4. (a) Apply the steady flow energy equation and show that the enthalpy of fluid before throttling is equal to that after the throttling. (3)

(b) A gas undergoes a thermodynamic cycle consisting of the following processes: (7)

Process 1-2 ; Constant Pressure $p_1 = 1.4\,\text{bar}, V_1 = 0.028m^3,\ W_{12} = 10.5kJ$

Process 2-3 ; Compression with $pV = \text{Constnat}\, U_3 = U_2$

Process 3-1 ; Constant volume $U_1 - U_3 = -26.4kJ$

There are no significant changes in KE and PE.

(i) Sketch the cycle on a p-V diagram

(ii) Calculate the network for the cycle

(iii) Show that $\sum_{Cycle} Q = \sum_{Cycle} W$

5. (a) Establish the equivalence of Kelvin-Planck and Clausius statement. (3)

(b) A reversible heat engine operating between two reservoirs at temperatures of 500°C and 50°C drives a refrigerator. The refrigerator operates between reservoirs at temperatures of 50°C and − 20°C. The heat transfer to the heat engine is 2500 kJ and the network output of the combined engine and refrigerator is 400 kJ. (7)

(i) Evaluate the heat transfer to the refrigerator and

(ii) Net heat transfer to the reservoir at 50°C

6. (a) Why is an isentropic process not necessarily an adiabatic process? (3)

(b) 2 kg of ice at 0°C is exposed to the atmosphere, which is at 30°C. The ice melts and comes into thermal equilibrium with the atmosphere Determine the entropy increase of the universe. The latent heat of fusion of ice is 333.3 kJ/kg. (7)

7. (a) With the help of p-v and T-s diagram, show that for the same compression ratio and heat rejection, (3)

$$\eta_{otto} > \eta_{duel} > \eta_{diesel}$$

(b) An engine working on Otto cycle has an air standard cycle efficiency of 56%. The compression of air begins at 35°C, 0.1 MPa. The maximum temperature of the cycle is 1100°C. Find (7)

(i) Temperature and pressure at the cardinal points of the cycle,

(ii) The heat supplied per kg.

8. (a) Explain the significance of the ultimate analysis of solid fuel? (3)

(b) The percentage composition by mass of a solid fuel used in a boiler is given below:

$C = 90\%$, $H_2 = 3.5\%$, $O_2 = 3\%$, $N_2 = 1\%$, $S = 1\%$ and the remainder is ash.

(i) Estimate the mass of air required per kg of fuel for complete combustion and perform mass analysis of the dry products of combustion. (7)

(ii) If 50% excess air is supplied in actual combustion, determine the total volume of the dry products.

9. (a) Draw the phase equilibrium diagram of pure substance which shrinks in volume on melting. (3)

(b) A steam turbine working on Rankine cycle is supplied with dry saturated steam at 25 bar and the exhaust takes place at 0.2 bar. For a steam flow rate of 10 kg/s, determine (7)

(i) Quality of steam at the end of expansion

(ii) Turbine shaft work

(iii) Power required to drive the pump

(iv) Rankine efficiency