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BME-019

B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING) / BTMEVI

Term-End Examination

00193

December, 2018

BME-019 : ENGINEERING THERMODYNAMICS

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt any* ***seven*** *questions. Question no* ***1*** *is* ***compulsory****. All questions carry equal marks. Use of scientific calculator and steam table is allowed.*

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1. Choose the correct answer from the given four alternatives. *10×1=10*

   (a) Which one of the following is the basis of temperature measurement ?

   (i) Zeroth law of thermodynamics

   (ii) First law of thermodynamics

   (iii) Second law of thermodynamics

   (iv) Law of stable equilibrium

(b) Internal energy is defined by the

(i) Zeroth law of thermodynamics

(ii) First law of thermodynamics

(iii) Second law of thermodynamics

(iv) Law of entropy

(c) Perpetual motion machine of the second kind violates the

(i) First law of thermodynamics

(ii) Kelvin – Planck statement

(iii) Clausius statement

(iv) Third law of thermodynamics

(d) Heat transferred to a system at constant pressure is equal to

(i) work transfer

(ii) change in internal energy

(iii) change in enthalpy

(iv) change in entropy

(e) The relation

$$du = T\,ds - p\,dv$$ is true for

(i) reversible processes only

(ii) reversible adiabatic processes only

(iii) all processes

(iv) a reversible cycle only

(f) The entropy of a system

(i) can never decrease

(ii) can never increase

(iii) may increase or decrease

(iv) will always remain constant

(g) For real gases $C_p = C_v$ at

(i) critical temperature

(ii) triple point

(iii) all temperatures

(iv) absolute zero temperature

(h) The work done by a closed system will increase when the value of the polytropic index n

(i) increases

(ii) decreases

(iii) first decreases and then increases

(iv) first increases and then decreases

(i) Torr is a unit of

(i) temperature

(ii) pressure

(iii) volume

(iv) energy

(j) Which one of the following is ***not*** a point function ?

(i) Temperature

(ii) Pressure

(iii) Energy

(iv) Power

2. (a) What is the Zeroth law of thermodynamics ?

(b) The temperature t on a thermometric scale is defined in terms of a property K by the relation

$$t = a \ln K + b,$$

where a and b are constants. The values of K are found to be 1·83 and 6·78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of K equal to 2·42 on the thermometer. *2×5=10*

3. (a) A single-cylinder, double-acting, reciprocating water pump has an indicator diagram which is a rectangle 0·075 m long and 0·05 m high. The indicator spring constant is 147 MPa per m. The pump runs at 50 rpm. The pump cylinder diameter is 0·15 m and the piston stroke is 0·20 m. Find the rate at which the piston does work on the water.

(b) 680 kg of fish at 5°C are to be frozen and stored at – 12°C. The specific heat of fish above freezing point is 3·182 kJ/kg K and below freezing point is 1·717 kJ/kg K. The freezing point is – 2°C and the latent heat of fusion is 234·5 kJ/kg. How much heat must be removed to cool the fish, and what percent of this is latent heat ? *2×5=10*

4. (a) When a system is taken from state a to state b, as shown in Figure 1, along path acb, 84 kJ of heat flows into the system and the system does 32 kJ of work.

(i) How much will the heat that flows into the system along path adb be, if the work done is 10·5 kJ ?

(ii) When the system is returned from b to a along the curved path, the work done on the system is 21 kJ. Does the system absorb or liberate heat, and how much of the heat is absorbed or liberated ?

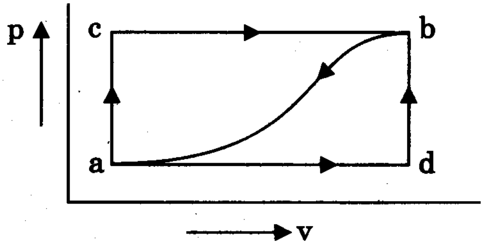

Figure 1

(b) The properties of a certain fluid are related as follows :

$$u = 196 + 0{\cdot}718\, t$$
$$pv = 0{\cdot}287\, (t + 273)$$

where u is the specific internal energy (kJ/kg), t is in °C, p is pressure (kN/m^2) and v is specific volume (m^3/kg). For this fluid, find C_v and C_p. *2×5=10*

5. (a) A mass of 8 kg gas expands within a flexible container so that the p-v relationship is of the form

$$pv^{1{\cdot}2} = \text{constant}.$$

The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, find the heat transfer in magnitude and direction.

(b) State the Kelvin–Planck statement of the Second law of thermodynamics. *2×5=10*

6. (a) Show that the COP of a heat pump is greater than the COP of a refrigerator by unity.

(b) An inventor claims to have developed an engine that takes in 105 MJ at a temperature of 400 K, rejects 42 MJ at a temperature of 200 K and delivers 15 kWhr of mechanical work. Do you agree with the claim of the inventor ? Justify your statement. *2×5=10*

7. (a) A heat engine is used to drive a heat pump. The heat transfers from the heat engine and from the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the heat engine is 27% and the COP of the heat pump is 4. Evaluate the ratio of the heat transfer to the circulating water to the heat transfer to the heat engine.

(b) What are the causes of entropy increases? *2×5=10*

8. Consider an engine in outer space which operates on the Carnot cycle. The only way in which heat can be transferred from the engine is by radiation. The rate at which heat is radiated is proportional to the fourth power of the absolute temperature and to the area of the radiating surface. Show that for a given power output and a given T_1, the area of the radiator will be a minimum when $\frac{T_2}{T_1} = \frac{3}{4}$. *10*

9. (a) Steam initially at 1·5 MPa, 300°C expands reversibly and adiabatically in a steam turbine to 40°C. Determine the ideal work output of the turbine per kg of steam.

(b) A rigid vessel of volume 0·86 m^3 contains 1 kg of steam at a pressure of 2 bar. Evaluate the specific volume, temperature and dryness fraction. *2×5=10*

10. (a) Explain in brief the working principle of a steam power plant with the help of a neat diagram.

(b) What is the effect of regeneration on the

(i) specific output,

(ii) cycle efficiency, and

(iii) steam rate of a steam power plant ? *2×5=10*