BYJU'S EXAM PREP

AE/JE Foundation

Mechanical Engineering

Thermodynamics

Top 100 Most Expected Questions

1. Zeroth law of thermodynamic defines

A. internal energy
B. enthalpy
C. temperature
D. pressure

Ans. C

Sol. Zeroth law of thermodynamics states about thermal equilibrium of bodies.

2. If a heat engine produces work without the consumption of energy, then what kind of machine is this?

A. Perpetual motion machine of first kind (PMM1)
B. Perpetual motion machine of second kind (PMM2)
C. Perpetual motion machine of third kind (PMM3)
D. None of these

Ans. A

Sol. This kind of device is impossible.

PMM1 is a hypothetical engine which develops work without receiving the heat energy.

3. The quantity of heat required to change the temperature of 1 gm of ice from -6 °C to -5 °C is known as

A. Latent heat of freezing
B. Freezing heat
C. Heat of vaporization
D. Specific heat

Ans. D

Sol. Specific heat is the correct answer(option 4)

Specific heat capacity (*C*) is used for calculations that involve a temperature change, but no phase change. For liquid water, C=4.184 J/(g·°C).

Since there is no phase change only temperature change so it is specific heat.

4. For a steady flow process in a turbine from state 1 to state 2, h_1= 450 kJ/kg, h_2= 150 kJ/kg and entropy changes from s_1 = 1.2 kJ/kgK to s_2 = 0.8 kJ/kgK. Ambient is at 300 K. Find the change in availability (kJ) __________.

A. 175
B. 180
C. 186
D. 182

Ans. B

Sol. Given:

h_1= 450kJ/kg

h_2= 150kJ/kg

s_1= 1.2 kJ/kgK and s_2= 0.8 kJ/kgK

T_o= 300K

Since turbine is open system.

Change in availability of open system = $h_1 - h_2 - T_o (s_1 - s_2)$

Change in availability of open system = 450−150−300(1.2−0.8) = 180 kJ

5. Two Sources are 1 and 2 supplies energy respectively at the rate of 11500 kJ/min at 350 °C & 115000 kJ/min at 85 °C. What source would supply energy to an ideal reversible heat engine that is to produce large amount of power if the temp of the surroundings is 32 °C?

A. Choose Source 1
B. Choose Source 2
C. Choose Both
D. None Of The Above

Ans. B

Sol. Source 1:

Rate of supply of energy = 11500 kJ/min

Temperature, T_1 = 350 + 273 = 623 K.

Source 2:

Rate of supply of energy = 115000 kJ/min

Temperature, T_1 = 85 + 273 = 358 K

Temperature of the surroundings, T_2 = 32 °C + 273 = 305 K

In this case Carnot cycle engine be working in the two cases with the two source temperatures and the single sink temperature.

The efficiency of the cycle will be given by:

$$\eta_1 = 1 - \frac{T2}{T1} = 1 - \frac{305}{623} = 0.5104 \text{ or } 51.04\%$$

$$\eta_2 = 1 - \frac{T2}{T1} = 1 - \frac{305}{358} = 0.148 \text{ or } 14.8\%$$

∴ The work delivered in the two cases is given by

$W_1 = 11500 \times 0.5104 = 5869.6$ kJ/min

And $W_2 = 115000 \times 0.148 = 17025$ kJ/min.

Thus, choose source 2. (Ans.)

6. A 4 kW, 20 liter water heater is switched on for 10 minutes. The heat capacity Cp for water is 4 kJ/kg-K. Assuming all the electrical energy has gone into heating the water, what is the increase of the water temperature (in °C)?

A. 10
B. 20
C. 30
D. 40

Ans. C

Sol. $m \times Cp \times \Delta T = Q$; assuming the density of water is 1000 kg/m^3,

$m = 20/1000 \times 1000 = 20$ kg

$Q = 4 \times 1000 \times 10 \times 60 = 2.4 \times 10^6$

$2.4\times10^6 = 20\times4\times1000\times\Delta T$; $\Delta T = 30$ °C

7. The system liberates 84 kJ of heat when changing from state A to B. If the internal energies of state A is 0 while that of state B is 28 kJ. Determine the work done during the process.

A. 56 kJ by the system
B. 56 kJ on the system
C. 112 kJ by the system
D. 112 kJ on the system

Ans. D

Sol. Given: Q_{a-b} = -84 kJ

U_1 = 0 kJ

U_2 = 28 kJ

Therefore,

$Q_{a-b} = \Delta E + W_{a-b}$

$-84 = 28 - 0 + W_{a-b}$

W_{a-b} = -112 kW

8. Which of the following is a closed system?

A. Air conditioned railway coach

B. Biogas digester

C. Sun

D. Fountain pen while writing

Ans. C

Sol. A closed system is defined when a particular quantity of matter is under study. A closed system always contains the same matter. There can be no mass transfers across the boundary. There may be energy transfer across the boundary. Sun transmits only energy but it doesn't transmit any mass hence it is a closed system.

9. A house refrigerator with its door open is switched on in a closed room. The air in the room is

A. cooled

B. remains at same temperature

C. heated

D. heated or cooled depending on atmospheric pressure

Ans. C

Sol. In any refrigerator a certain amount of heat Q2 is absorbed from the objects you want to cool and a larger amount of heat Q1 is released to the outside through the radiator behind the refrigerator. If you keep your hand on the radiator, it will feel warm. When the door of the refrigerator is kept open, the compressor will work all the time as the heat in the room is too large and the temperature never reaches the cutoff point of the thermostatic switch. So more heat is released into the room than what is absorbed. If the ventilation is insufficient this will cause the room to warm up.

10. Specific entropy of a system of 50 kg mass, increases from 0.7 kJ/kgK to 0.8 kJ/kgK. At the same time the entropy of surroundings decreases from 160 kJ/K to 150 kJ/K. The process is

A. Reversible isotherm

B. Irreversible

C. Reversible

D. Impossible

Ans. D

Sol. Entropy change of the system $= m\Delta s = 50(0.8 - 0.7) = 5kJ / K$

Entropy change of the surroundings = 150 – 160 = -10 kJ/K

Then, Entropy change of the universe will be

$$\Delta S_{uni} = \Delta S_{sys} + \Delta S_{surroundings} = 5 - 10 = -5\frac{kJ}{K}$$

Which is impossible because entropy of universe always increases.

11. Evaluate the dryness fraction (quality) of steam which has 1.5 kg of water in suspension with 60 kg of steam.

A. 1.876

B. 0.976

C. 1.676

D. 0.276

Ans. B

Sol. Mass of dry steam, m_s = 60 kg

Mass of water in suspension, m_w = 1.5 kg

$$\therefore \text{ Dryness fraction, } x = \frac{\text{Mass of dry steam}}{\text{Mass of dry steam+mass of water in suspension}}$$

$$= \frac{ms}{ms + mw}$$

$$= \frac{60}{60 + 1.5}$$

= 0.976

12. For a particular ideal gas, the value of R is 0.280 kJ/kgK and the value of γ is 1.375. The flue of C_p and C_v are, respectively, in kJ/kgK:

A. 1.25, 0.8

B. 1.0267, 0.7467

C. 1.111, 0.66

D. 1.2, 0.70

Ans. B

Sol. As we know,

$$C_P = \frac{\gamma R}{\gamma - 1} \text{ and } C_V = \frac{R}{\gamma - 1}$$

$$C_p = \frac{1.375 \times 0.28}{1.375 - 1} = 1.0267$$

$$C_V = \frac{0.28}{1.375 - 1}$$

= 0.746

Hence, C_P = 1.0267 kJ/kgK and C_V = 0.746 kJ/kgK

13. As per Gibbs phase rule, the relation between number of components (C), phases (P) and degree of freedom (F) is

A. P + C – F = 2

B. P + F – C = 2

C. C + F + P = 2

D. C – F – P = 2

Ans. B

Sol. According to Gibbs phase rule the correct relation is

P + F = C + 2

So the correct option is (b).

14. Characteristic gas constant of a gas is equal to

A. C_p / C_v B. C_v /C_p

C. C_p - C_v D. C_p + C_v

Ans. C

Sol. Characteristic Gas Constant, R= C_p - C_v

15. Two air streams with mass flow rates of 36 kg/ min and 14 kg/min with respective enthalpies of 36 kJ/kg da and 50 kJ/kg da are mixed. The enthalpy of the mixture is nearly

A. 64 kJ/kg da B. 55 kJ/kg da

C. 46 kJ/kg da D. 40 kJ/kg da

Ans. D

Sol. Let h be the enthalpy after mixing.

We know that the energy before mixing will be equal to the energy after mixing.

Hence, $(m_1 + m_2)h = m_1h_1 + m_2h_2$

$(36 + 14)h = 36 \times 36 + 14\times50$

$$h = \frac{1296 + 700}{50} = 39.92 kJ / kg$$

16. Determine higher temperature of the cycle. C.O.P. of Carnot refrigerator is 2.99 and Carnot refrigerator requires 1.5 kW per tonne of refrigeration to maintain a region at low temp of -33 ^oc.

A. 43.26 ^{o}C B. 45.26 ^{o}C

C. 47.26 ^{o}C D. 49.26 ^{o}C

Ans. C

Sol. Given T2 = 273-33 = 240 K; power required per tonne of refrigerator = 1.5 kW

<u>Higher temperature of the cycle:</u>

C.O.P. (Carnot ref.) = T2 / (T1 – T2)

i.e., 2.99 = 240 / (T1 - 240)

∴ T1 = (240 / 2.99) +240

= 320.26 K

= 320.26 – 273

= 47.26 ^{o}C

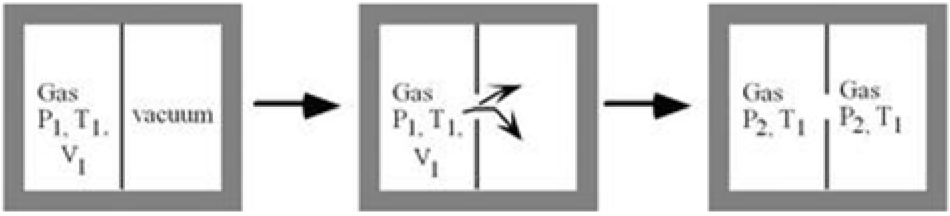
17. If a fluid expands suddenly into vacuum through an orifice of large dimension, then such a process is called ______.

A. free expansion B. hyperbolic expansion

C. adiabatic expansion D. parabolic expansion

Ans. A

Sol.



18. One kilogram of water at room temperature is brought into contact with a high temperature thermal reservoir either. The entropy change of the universe is

A. equal to entropy change of the reservoir

B. equal to entropy change of water

C. equal to zero

D. always positive

Ans. D

Sol. In every case, entropy of universe is always either zero or positive. It is zero for reversible process and positive for irreversible process.

(ΔS) universe ≥ 0

$\Delta S_{system} + \Delta S_{surrounding} \geq 0$

Here, there is a finite temperature difference between the water and thermal reservoir and therefore the process is irreversible. Hence, entropy change of the universe is positive.

19. 5 m^3 of an ideal gas at 1 bar pressure is compressed isothermally in an adiabatic piston-cylinder device to 2 m^3. Maximum work input needed by the compressor is

A. 250 Kj

B. 300 kJ

C. 500 Kj

D. Compression is not possible

Ans. D

Sol. Isothermal adiabatic compression process is not possible because:

$\Delta U = 0$ for isothermal process

and $Q = 0$ for adiabatic process.

So, the first law relation, $Q - W = \Delta U$. Reduces to $W = 0$.

Therefore, this adiabatic system cannot-receive any net work at constant temperature.

20. An ideal gas when compressed to half of its initial volume in a constant temperature process, 600 J of energy is removed from gas during compression in the from of heat. What will be the change in internal energy?

A. 600

B. 500

C. 0

D. Not enough information

Ans. C

Sol. Since we have Energy (Q) as 600 J

Then according to first law of thermodynamics:

$\Delta U = Q - W$,

Where:

Q = thermal energy transferred into system

W = work done by system

If the temperature remains constant then:

$\Delta U = 0$

21. Entropy is a measure of ___________.

A. Reversible heat transfer
B. System efficiency
C. Degree of randomness
D. System temperature

Ans. C

Sol. Entropy is a thermodynamic property that measures the degree of randomization or disorder at the microscopic level.

It is explained by second law of thermodynamics which says that the energy degrades to less useful form while conversion.

22. Air enters a turbine steadily at 16 MPa and 800 K and exists at 1 MPa and 400 K in an environment at 27°C . The decrease in exergy of steam as it flows through the turbine (in kJ/kg) is (Assume no heat loss)(C_p =1 kJ/KgK,R = 0.3 KJ/KgK)

A. 110
B. 41.5
C. 35
D. 75

Ans. B

Sol. P_1 = 16000kPa

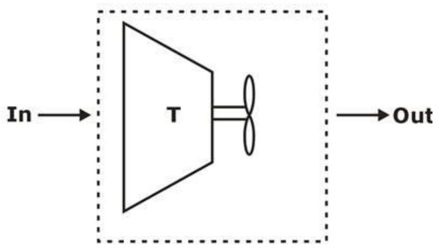
P_2 = 1000 kPa

T_1 = 800 k

T_2 =400 k

T_0 =300 k

Turbine is an open system.



Exergy balance

$\varphi_{in} - \varphi_{out} = \Delta\varphi + I$

$\Delta\varphi = 0$

$I = \varphi_{in} - \varphi_{out}$

$I = (H_1 - H_2) - T_0 (S_1 - S_2) - W_{act}$.

By SFFE

$W_{act} = H_1 - H_2$

$I = - T_0(S_1 - S_2)$

$$S_1 - S_2 = C_p \ln\left(\frac{T_1}{T_2}\right) - R\ln\left(\frac{P_1}{P_2}\right)$$

$$= 1 \times \ln\left(\frac{800}{400}\right) - 0.3\ln\left(\frac{16000}{1000}\right)$$

$S_1 - S_2 = \ln 2 - 0.3 \ln 16$

$S_1 - S_2 = \ln 2 - 1.2\ln 2$

$S_1 - S_2 = -0.2 \ln 2$

$S_1 - S_2 = -0.1386$

$I = -300 (-0.1386)$

$I = 41.58$ kJ

23. The Helmholtz function F is given by __________.

A. U – TS

B. U + TS

C. –U – TS

D. –U + TS

Ans. A

Sol. Helmholtz free energy in thermodynamics is a thermodynamic potential which is used to measure the work of a closed system with constant temperature and volume. It is given by:

$F = U - TS$

Where,

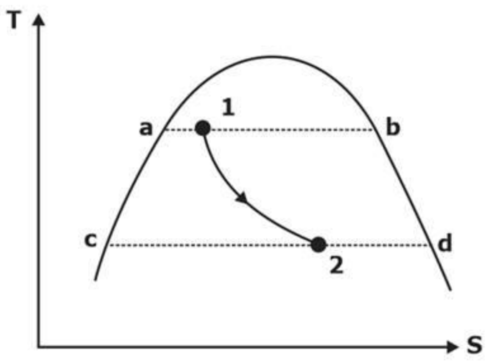
F is the Helmholtz free energy in Joules

U is the internal energy of the system in Joules

T is the absolute temperature of the surroundings in Kelvin

S is the entropy of the system in joules per Kelvin

24. The enthalpy of the wet steam after throttling (from 1 to 2) is ______ kJ/kg. The process and properties is as shown below:



h_a = 30 kJ/kg

h_b = 250kJ/kg

x_1 = 0.4

A. 118 B. 121

C. 116 D. 124

Ans. A

Sol. $h_1 = h_a + x_1 h_{ab}$

$h_1 = h_a + x_1(h_b - h_a)$

$h_1 = 30 + 0.4\ (250 - 30)$

h_1 = 118 kJ/kg

∴ throttling is an isoenthalpic process,

∴ $h_1 = h_2$

h_2 = 118 kJ/kg

25. A heat pump which is used in a house for heating purpose. Heat pump absorbs heat from cold air outside in winter and send heat to the house.if the Work required to extract the heat form the outside is 3.3×10^4 kJ/h and the amount of heat supplies to the house is 2.5×10^5 kJ/h. Then what will be the heat extracted from the surrounding and the COP of the heat pump.

A. 170000 kJ/h; 6.58 B. 217000 kJ/h; 7.58

C. 217000 kJ/h; 8.58 D. 228000 kJ/h; 7.58

Ans. B

Sol. Heat requirement of the house, Q_1 (or heat rejected)

$= 2.5 \times 10^5$ kJ/h

Work required to operate the heat pump,

$W = 3.3 \times 10^4$ kJ/h

Now, $Q_1 = W + Q_2$

Where Q_2 is the heat abstracted from outside.

∴ $2.5 \times 10^5 = 3.3 \times 10^4 + Q_2$

Thus $Q_2 = 2.5 \times 10^5 - 3.3 \times 10^4$

= 250000 – 33000

= 217000 kJ/h

Hence, heat abstracted from outside = 217000 kJ/h. (Ans.)

$$(\text{C.O.P.})_{\text{heat pump}} = \frac{Q1}{Q1 - Q2}$$

$$= \frac{25 \times 10^4}{3.3 \times 10^4} = \frac{25}{3.3} = 7.575$$

Hence, co-efficient of performance = 7.58

26. Critical point of water is

A. 273 K
B. 374 K
C. 374.2ºC
D. 374°F

Ans. C

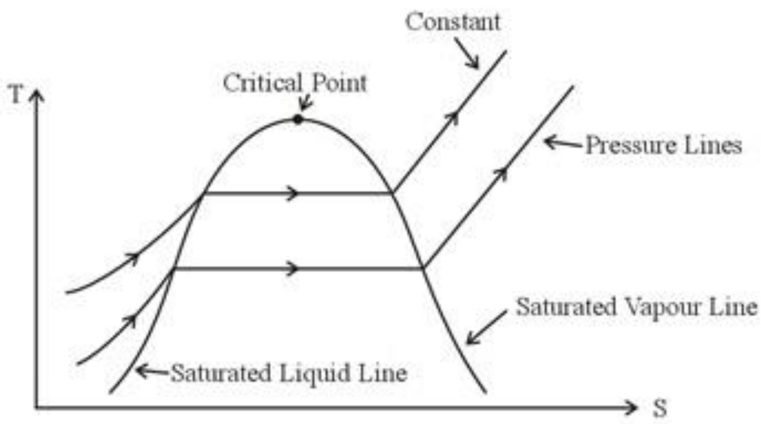
Sol. The point, where saturated liquid and saturated vapour line meets in the T-S diagram of water is called critical point and the temperature, pressure and specific volume corresponding to this point is called critical temperature(T_c), critical pressure(P_c) and critical specific volume (v_c).

For water,

T_c = 374.2 °C

P_c = 221.2 bar

v_c = 0.00317 m^3/kg



27. A heat engine receives heat from a source at 1500 K at a rate of 450 kW and rejects the waste heat to a medium at 300 K. The power output of the heat engine is 180 kW. Determine the irreversibility rate for this process __________.

A. 180kW
B. 150kW
C. 360kW
D. 200kW

Ans. A

Sol. Given:

T_1= 1500 K

T_2= 300 K

Q= 450 kW

Useful work (W_{useful}) = 180 kW

Maximum Work:

$$W_{max} = Q \times \left(1 - \frac{T_2}{T_1}\right) = 450 \times \left(1 - \frac{300}{1500}\right) = 360kW$$

Irreversibility (I) = W_{max} - W_{Useful} = 360 −180=180 kW

28. The maximum theoretical work obtainable, when a system interacts to equilibrium with a reference environment, is called __________.

A. Entropy
B. Enthalpy
C. Exergy
D. Rothalpy

Ans. C

Sol. As per the definition of the Exergy (or) Available Energy, the maximum portion of energy which could be converted into useful work by ideal processes which reduce the system to dead state is known as Exergy.

29. Kelvin Planck's law deals with the ____________.

A. conservation of heat
B. conservation of work
C. conversion of heat into work
D. conservation of work into heat

Ans. C

Sol. Kelvin–Planck law states that it is impossible to devise a cyclically operating device, the sole effect of which is to absorb energy in the form of heat from a single thermal reservoir and to deliver an equivalent amount of work.

30. Efficiency of Carnot engine is 50%. If the cycle direction is reverse, COP of the refrigerator working on reversed Carnot cycle will be _________.

A. 1
B. 2
C. 1.5
D. 3

Ans. A

Sol. Given:

$\eta_{Engine} = 0.50$

$$\eta_{Engine} = \frac{T_1 - T_2}{T_1}$$

and $(COP)_{HP} = \dfrac{T_1}{T_1 - T_2} = \dfrac{1}{\eta_{Engine}}$

$$COP_R = COP_{HP} - 1$$

$$(COP)_{Ref} = \frac{1}{\eta_{Engine}} - 1$$

$$(COP)_{Ref} = \frac{1}{0.50} - 1 = 1$$

31. A steam nozzle coverts ___________.

A. kinetic energy into heat
B. heat energy into potential energy
C. potential energy into heat
D. heat energy into kinetic energy

Ans. D

Sol. The steam nozzle is to increase the kinetic energy of the flowing medium at the expense of its pressure and internal energy.

32. The COP of a Carnot refrigerator is 6. The ratio of its lower and higher absolute temperature is :

A. $\frac{7}{8}$

B. $\frac{1}{7}$

C. $\frac{1}{6}$

D. $\frac{6}{7}$

Ans. D

Sol. The COP of a Carnot refrigerator is given by :

$$COP = \frac{T_L}{T_H - T_L}$$

$$6 = \frac{T_L}{T_H - T_L}$$

$$6T_H - 6T_L = T_L$$

$$7T_L = 6T_H$$

$$\frac{T_L}{T_H} = \frac{6}{7}$$

33. When a reversible process undergoes a complete cycle then the change of entropy will be

A. + ve value

B. -ve value

C. zero value

D. + ve or – ve value depending on initial condition

Ans. C

Sol. Entropy is a property; hence in a cycle of reversible process, initial and final value remains same. Hence, the change in entropy is zero.

34. A perfect gas (specific heat of constant pressure 1 KJ/kg K). The temperatures of the gas of turbine at entry and exit are 927 °C and 27 °C, respectively. The power produced is 1.8 MW. The mass flow rate of the gas (in kg/s) through the turbine is

A. 1.89

B. 2

C. 1.94

D. 3

Ans. B

Sol. Given,

Specific heat of constant pressure (C_P)= 1 KJ/kg K

By S.F.E.E.

$h_1 = h_2 + W$

$\Rightarrow W = h_1 - h_2$

$1800 = m \times 1(927 - 27)$

$\Rightarrow m = 2$ kg/sec

35. Degree of freedom of critical point is

A. 0
B. 1
C. 2
D. can’t be determined

Ans. A

Sol. Degree of freedom of critical point is zero.

we know that , P+F = C + 2

number pf phases (P)=3,

number of components (C)=1

hence, from this we get number of degrees of freedom (F) = 0.

36. Which Thermodynamics law predicts correctly, about the feasibility/directionality of the process ___________?

A. Zeroth law
B. First law
C. Second law
D. Third law

Ans. C

Sol. Direction of any process is govern by the entropy value which is defined in the Second law of thermodynamics.

Thus, Second law of thermodynamics provides the direction of possible energy conversion through the concept of entropy.

37. In a Carnot cycle, heat is transferred at _______________.

A. constant pressure
B. constant volume
C. constant temperature
D. constant enthalpy

Ans. C

Sol. Carnot cycle include

Two isentropic (compression and expansion)

Two isothermal (heat addition and heat rejection)

38. The enthalpy drop for flow through convergent horizontal nozzles is 100 kJ/kg. If the velocity of approach at inlet to the nozzle is negligible, the exit velocity of the fluid is

A. 20 m/s
B. 400 m/s
C. 447.2 m/s
D. 520.8 m/s

Ans. C

Sol. Enthalpy drop (dh)= h1-h2= 100kJ/kg

Applying steady flow energy equation at inlet and exit of nozzle and neglecting change in datum and assuming no heat and work transfer

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

$$V_1 = 0$$

$$V_2 = \sqrt{2(h_1 - h_2)}$$

$$V_2 = \sqrt{2(100 \times 1000)}$$

$$V_2 = 447.2 m/s$$

39. One kg of steam sample contains 0.8 kg dry steam; it's dryness fraction is

A. 0.2
B. 0.8
C. 0.6
D. 0.5

Ans. B

Sol.

mass of sample steam = 1kg

mass of dry steam = 0.8kg

$$\text{dryness fraction} = \frac{m_v}{m_s} = \frac{0.8}{1} = 0.8$$

40. An amount of 100 kW of heat is transferred through a wall in steady state. One side of the wall is maintained at 127 °C and the other side at 27 °C. The entropy generated (in W/K) due to the heat transfer through the wall is _______

A. 83
B. 57
C. 46
D. 98

Ans. A

Sol. Entropy Generation;

$$\frac{ds}{dt} = \int_1^2 \frac{d\theta}{T} + (\Delta s)_{gen}$$

at steady state, the LHS of the above equation becomes zero, therefore

$$0 = \left(\frac{100}{400} - \frac{100}{300}\right) + (\Delta s)_{gen}$$

$(\Delta s)_{gen}$ = 0.083 kW/K or 83 W/K

41. A saturated liquid at a pressure of 25 kPa is throttled to a lower pressure of 5kPa. The following table indicates the properties of this substance:-

Pressure (KPa)	h_f (kJ/kg)	h_g (kJ/kg)	v_f (m^3/kg)	V_g (m^3/kg)
5	700	3800	0.00213	0.007
25	1000	3500	0.0003	0.0025

Calculate the dryness fraction of vapours after throttling process:

A. 0.067
B. 0.097
C. 0.087
D. 0.97

Ans. B

Sol. At 25 KPa, $h_1 = h_{f1}$ = 1000 kJ/kg

At 5 KPa, h_{f2} = 700 kJ/kg, h_{g2} = 3800 kJ/kg

Let x_2 = Dryness fraction after throttling

For throttling $h_1 = h_2$

$h_1 = h_{f2} + x_2 (h_{g2} - h_{f2})$

$1000 = 700 + x_2 (3800 - 700)$

$X_2 = 0.09677$

42. A cylinder contains 5m of an ideal gas at a pressure of 1 bar. This gas is compressed in a reversible isothermal process till its pressure increases to 5 bar. The work in kJ required for this process is

A. 804.7
B. 953.2
C. 981.7
D. 1012.2

Ans. A

Sol. For a reversible isothermal process work done is calculated as:

$$W = P_1V_1 \ln\frac{P_1}{P_2} = 100 \times 5 \times \ln\left(\frac{1}{5}\right) = -804.7\text{kJ}$$

The negative sign shows that the system is undergoing compression process.

43. A heat engine is used to drive the refrigerator. Efficiency of heat engine and COP of refrigerator are 60% and 5 respectively. Heat input (in kJ/sec) needed to the heat engine from the higher temperature source for each ton of refrigeration is

A. 1.00
B. 0.58
C. 1.17
D. 2.33

Ans. C

Sol. $\eta_{HE} = \frac{W}{Q_1} = 0.6$ .... (1)

$(COP)_{ref.} = \frac{Q_2}{W} = 5$ ....(2)

Multiplying equation (1) and (2), we get

$$= \frac{Q_2}{Q_1} = 0.6 \times 5 = 3$$

Given, Q_2 = 1 ton of of refrigeration= 3.5kJ/s

$$\frac{3.5}{Q_1} = 3$$

$$Q_1 = \frac{3.5}{3} = 1.17$$

44. Exergy of atmosphere is ___.

A. Zero
B. Negative
C. Positive
D. Infinite

Ans. A

Sol. Atmosphere around us contains a tremendous amount of energy but atmosphere is in dead state, hence no exergy.

45. For an ideal gas, the value of $\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P$ is ____________.

A. $-\frac{T}{P}$
B. $-\frac{P}{T}$
C. $\frac{T}{P}$
D. $\frac{P}{T}$

Ans. B

Sol. From Ideal gas equation we have

PV =mRT

Taking partial derivative of the above equation with respect to volume assuming temperature to be constant.

$$\therefore \frac{\partial P}{\partial V} V + \frac{\partial V}{\partial V} P = 0$$

$$\therefore \left(\frac{\partial P}{\partial V}\right)_T = -\frac{P}{V}$$

Now, taking partial derivative of ideal gas equation with respect to temperature at constant pressure we get

$$\frac{\partial V}{\partial T} P = mR \frac{\partial T}{\partial T}$$

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{mR}{P} = \frac{V}{T}$$

$$\therefore \left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P = -\frac{P}{V} \times \frac{V}{T} = -\frac{P}{T}$$

46. Availability of a system at any given state is

A. a property of the system

B. the minimum work obtainable as the system goes to dead state

C. the total energy of the system

D. the maximum useful work obtainable as the system goes to dead state

Ans. D

Sol. Availability is defined as the maximum useful work (total work minus pdV work) obtained in a process as system goes to dead state.

47. The resistance in copper winding of a motor is 100ohms at 25 °C. When operating at full load the resistance was found to be 150 ohms. The resistance is related to temperature by following equation.

$R_t = R_0$ (1+0.0693t) where R_0 is the resistance at 0 °C, T is temperature in °C. Find the temperature of the coil at full load.

A. 56 ºC

B. 44.7 ºC

C. 48 ºC

D. 53.5 ºC

Ans. B

Sol. Resistance at 25 °C =100ohms

$R_{25} = R_0$ (1+0.0693×25)

100 = R_0(2.7325)

R_0 = 36.596ohms

At full load resistance of 150ohms is given

$150 = 36.596(1+0.0693 \times t)$

$t = 44.715$ °C

48. For a closed system, the difference between heat added to the system and work done by the system, is equal to change in:

A. entropy

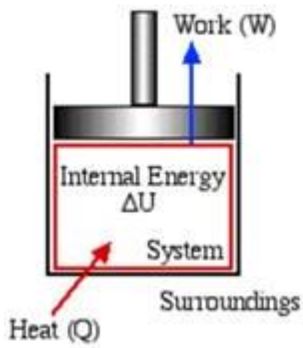
B. temperature

C. Internal energy

D. enthalpy

Ans. C

Sol. We consider the First Law of Thermodynamics applied to stationary closed systems as a conservation of energy principle. Thus energy is transferred between the system and the surroundings in the form of heat and work, resulting in a change of internal energy of the system. Internal energy change can be considered as a measure of molecular activity associated with change of phase or temperature of the system and the energy equation is represented as follows:



Energy equation for stationary closed systems.

$Q - W = \Delta U$

Where,

Q is heat transferred to the system.

W is the work done by the system.

ΔU is the change of Internal energy.

49. The slope of a Mollier-diagram at constant pressure indicates _______.

A. enthalpy

B. entropy

C. internal energy

D. Temperature

Ans. D

Sol. From 2nd law:

$Tds = dh - vdP$

For constant pressure $dP = 0$

$Tds = dh$

$\frac{dh}{ds} = T$ = Slope of mollier-diagram at constant pressure.

50. An isothermal process is one in which :

A. The pressure of the gas in the system is proportional to the volume of the gas.

B. The internal energy of the system under consideration decreases during the change.

C. The heat transfer of the system under consideration is zero.

D. The temperature of the system under consideration remains constant during the change.

Ans. D

Sol. An isothermal process is a change of a system, in which the temperature remains constant: $\Delta T = 0$.

An isothermal process is a change of a system, in which the temperature remains constant: $\Delta T = 0$. This typically occurs when a system is in contact with an outside thermal reservoir (heat bath), and the change occurs slowly enough to allow the system to continually adjust to the temperature of the reservoir through heatexchange. In contrast, an adiabatic process iswhere a system exchanges no heat with its surroundings ($Q = 0$). In other words, in an isothermal process, the value $\Delta T = 0$ and therefore $\Delta U = 0$ (only for an ideal gas) but $Q \neq 0$, while in an adiabatic process, $\Delta T \neq 0$ but $Q = 0$.

51. If a closed system is undergoing an irreversible process, the entropy of the system

A. Must increase

B. Always remains constant

C. Must decrease

D. Can increase, decrease or remain constant

Ans. D

Sol. Since nothing has been mentioned about the heat transfer so entropy can increase, decrease or remain constant depending upon the amount of heat added or rejected. Do not get confused with the change in entropy of the universe, which always increase for an irreversible process. Here, it is specifically asked about the change in entropy of the system.

52. For a reversible power cycle, the operating temperature limits are 800K and 300K. 400kJ of heat is supplied to this cycle from high temperature source.The unavailable work will be.

A. 250 kJ
B. 150 kJ
C. 120 kJ
D. 100 kJ

Ans. B

Sol. Given,

$T_H = 800K, \quad T_L = 300K$

$$\eta = 1 - \frac{T_L}{T_H} = 1 - \frac{300}{800}$$

$$\eta = \frac{5}{8}$$

$$\eta = \frac{W_{net}}{\text{Heat supplied}} \Rightarrow \frac{5}{8} = \frac{W_{net}}{400}$$

$W_{net} = 250kJ$

unavailable energy = heat supplied - work output

unavailable energy = 400- 250

unavailable energy = 150kJ

53. Entropy of wet stream (1 kg) is given by

A. $s_f + \frac{xh_{fg}}{T_s}$

B. $s_g + \frac{xh_{fg}}{T_s}$

C. $\frac{h_{fg}}{T_s}$

D. None of these

Ans. A

Sol. Entropy of wet steam:

$s = s_f + xs_{fg}$

$\because s_{fg} = \frac{h_{fg}}{T}$

$\therefore s = s_f + x\frac{h_{fg}}{T}$

T is constant saturation temperature.

The wet steam lies in liquid + vapour region. Entropy in wet zone is sum of entropy of saturated liquid+ entropy change for liquid to vapour transformation.

54. If the COP of Carnot refrigerator is 4, then the thermal efficiency of the Carnot engine would be ___________.

A. 0.33

B. 0.25

C. 0.2

D. 0.18

Ans. C

Sol. Given:

COP of refrigerator = 4

$$\eta_{th} = \frac{1}{1+(COP)_{ref}} = \frac{1}{1+4} = \frac{1}{5} = 0.2$$

55. A gas contained in a cylinder is compressed, the work required for compression being 5000 kJ. During the process, heat interaction of 2000 kJ causes the surroundings to the heated. The change in internal energy of the gas during the process is

A. -7000 kJ

B. −3000 kJ

C. +3000 kJ

D. + 7000 kJ

Ans. C

Sol. Given: W = – 5000 kJ (Negative sign shows that work is done on the system) & Q = – 2000 kJ (Negative sign shows that heat rejected by the system)

From the first law of thermodynamics,

$\Delta Q = \Delta W + \Delta U$

So, $\Delta U = \Delta Q - \Delta W = -2000 - (-5000)$

= – 2000 + 5000 = 3000 kJ

56. Isentropic flow is __________.

A. Reversible adiabatic flow
B. Irreversible adiabatic flow
C. Frictionless fluid flow
D. None of these

Ans. A

Sol. A simple more common definition of isentropic would be No change in entropy. An isentropic flow is a flow that is both adiabatic and reversible.

Hence (A) is correct.

57. A Carnot engine discharges 3kJ of heat into low temperature reservoir for every 2kJ of work output. If sink temperature is 27 °C then the value of source temperature is

A. 177°C
B. 227 °C
C. 500 °C
D. 277 °C

Ans. B

Sol. W = 2kJ

Q_l = 3kJ

W = Q_h-Q_l

2 = Q_h - 3

Q_h = 5kJ

efficiency= W/Q_h = 2/5

ξ = 1- (TL/T_H) = 1- 300/T_H

300/T_H = 3/5

$_{TH}$ = 500K = 227 °C

58. Using Clausius-Clapeyron's equation, estimate the enthalpy of vaporisation.

The following data is given:

At 200°C: vg = 0.1274 m^3/kg; v_f= 0.001157 m^3/kg;

$\frac{dP}{dT}$ = 32kPa/K.

A. 1687.34kJ/kg
B. 1910.8kJ/kg
C. 1789.24kJ/kg
D. 2136.47kJ/kg

Ans. B

Sol. Given,

At 200°C:

Saturated vapor (v_g) = 0.1274 m^3/kg;

Saturated liquid (v_f) = 0.001157 m^3/kg;

$\frac{dP}{dT}$ = 32kPa/K.

Using the equation,

$$\frac{dP}{dT} = \frac{h_{fg}}{T_{sat}\left(v_g - v_f\right)}$$

T_{sat} = 200 + 273 = 473K

$$32\times 10^3 = \frac{h_{fg}}{473(0.1274 - 0.001157)}$$

h_{fg} = 32× 10^3 × 473 × (0.1274-0.001157) = 1910.8kJ/kg

59. Which of the following is true with relative to basic thermodynamics?

A. In free expansion, Since vacuum does not offer any resistance, there is no work transfer involved in free expansion.

B. 100% heat can't be convertible to work but 100% work can be converted to heat. It depends on second law of thermodynamics.

C. Isentropic means reversible adiabatic. Heat transfer in any finite temp difference is irreversible

D. All of these

Ans. D

Sol. In free expansion, Since vacuum does not offer any resistance, there is no work transfer involved in free expansion.

100% heat can't be convertible to work but 100% work can be converted to heat. It depends on second law of thermodynamics.

Isentropic means reversible adiabatic. Heat transfer in any finite temp difference is Irreversible.

60. If 2 bar of air at 27 °C is heated to 177 °C at constant volume, the pressure will be

A. 6.56 bar

B. 3 bar

C. 9 bar

D. 13.11 bar

Ans. B

Sol. Given:

P_1= 2 bar

P_2= ?

T_1= 27 °C = 300 K

T_2= 177 °C = 450 K

Since this is a constant volume heat addition, therefore,

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$P_2 = \frac{2 \times 450}{300} = 3\text{bar}$$

61. The unit of power in S.I. units is:

A. Newton
B. Pascal
C. Joule
D. Watt

Ans. D

Sol. SI Unit of Power is Nm/s or Watts.

62. Which below stated statement is TRUE about a reservoir of heat?

A. It has a variable temperature
B. The heat exchange is reversible
C. It has a finite heat capacity
D. There exist no real heat reservoirs

Ans. B

Sol. Option B is correct explanation about reservoir and others are wrong.

Heat Reservoir is a hypothetical body of infinitely large mass capable of absorbing or rejecting unlimited quantities of heat without undergoing appreciable changes in temperature, pressure, or density. It works on second law of thermodynamics

63. Which of the following is reason of irreversibility?

A. Lack of equilibrium during the process
B. involvement of dissipative effects
C. None of the above
D. both a & b

Ans. D

Sol. A reversible process is carried out infinitely slowly, so that every state passed through by the system is an equilibrium state. In the irreversible process every state will not be an equilibrium state as it is carried out very fast. Only the first and the last state of the irreversible process are the equilibrium states. Therefore lack of equilibrium is a cause of irreversibility.

In a dissipative effect the energy is transformed from one form to another form and the final form of energy has a less capacity to do mechanical work. Thus this process becomes irreversible. Therefore involvement of dissipative effect is another cause of irreversibility.

64. Which of the relation represents an irreversible and possible process?

A. $\oint \frac{dQ}{T} = 0$
B. $\Phi \frac{dQ}{T} > 0$
C. $\Phi \frac{dQ}{T} < 0$
D. None of these

Ans. C

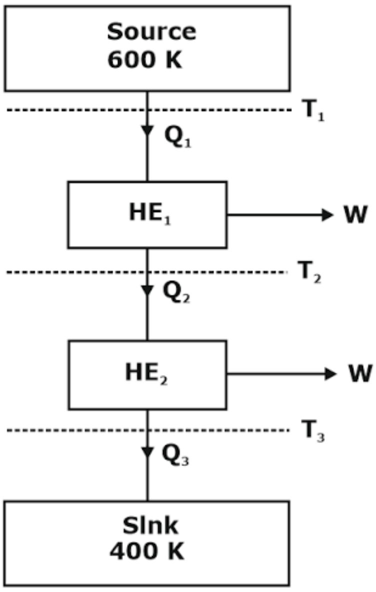
Sol. The relation between an irreversible and possible process are:

1. For reversible process: $\oint \frac{dQ}{T} = 0$

2. For irreversible and possible process: $\oint \frac{dQ}{T} < 0$

3. For impossible process: $\oint \frac{dQ}{T} > 0$

65. Two Carnot engines work in series between the sources and sink temperatures of 600 K and 400 K respectively and both engines develop equal power.The intermediate temperature (in K) is _____.



A. 480
B. 650
C. 500
D. 550

Ans. C

Sol. $T_1 = 600K$

$T_2 = 400K$

$$W_1 = \left(1 - \frac{T_2}{T_1}\right)Q_1$$

$$W_2 = \left(1 - \frac{T_3}{T_2}\right)Q_2$$

Since both engines develop equal power

$W_1 = W_2$

$$\left(1 - \frac{T_2}{T_1}\right)Q_1 = \left(1 - \frac{T_3}{T_2}\right)Q_2$$

$$\left(1-\frac{T_2}{T_1}\right)\frac{Q_1}{Q_2}=\left(1-\frac{T_3}{T_2}\right)$$

Since, $\frac{Q_1}{Q_2}=\frac{T_1}{T_2}$

$$\frac{T_1}{T_2}-1=1-\frac{T_3}{T_2}$$

$$T_2=\frac{T_1+T_3}{2}$$

$$T_2=\frac{600+400}{2}$$

$$T_2=500K$$

66. A fan is to accelerate quiescent air to a velocity of 12 m/s at a rate of 3 m^3/sec. If the density of air is 1.15 kg/m^3, the minimum power that must be supplied to the fan is ______ Watt.

A. 210.7
B. 230.56
C. 248.4
D. 270.5

Ans. C

Sol.

$$\text{Power}=\text{Rate of energy supplied}=m\left[\frac{C_2^2}{2}-\frac{C_1^2}{2}\right]$$

because the air is quiescent, therefore C_1 =0

$$\rho=\frac{\dot{m}}{\dot{v}}$$

$$\Rightarrow \dot{m}=\rho\dot{V}=1.15\times 3=3.45\text{kg / sec}$$

$$\therefore\ \text{Power}=3.45\times\left(\frac{12^2}{2}\right)=248.4\text{Watt}$$

67. A carnot cycle refrigerator 'A' operates between 500K and 900K, whereas a carnot cycle refrigerator 'B' operates between 300K and 500K. Find out the ratio of coefficient of performance of A to B

A. 1
B. 0.34
C. 0.83
D. 0.54

Ans. C

Sol. We know that, coefficient of performance (C.O.P) = $\frac{T_2}{T_1-T_2}$

C.O.P of A = $\frac{500}{900-500}=1.25$

C.O.P of B = $\frac{300}{500-300}=1.50$

So, ratio of C.O.P's = $\frac{COP_A}{COP_B}=\frac{1.25}{1.50}=0.83$

68. 8 Kg of water in a constant pressure container is agitated by a paddle unit, the temperature rises from 50°C to 90°C. The change in entropy (in KJ/K) of water is

A. 3.9
B. 4.3
C. 5.2
D. 9.4

Ans. A

Sol. Paddle agitation is an irreversible process. The change in entropy will, however, depend only on end states and not on the process. So, change in entropy will be same in irreversible process as would have been during reversible heating from 50°C to 90°C. (ΔS_{water}= mc ln(T_2/T_1) = 8 x 4.187 x ln (90+273 / 50+273) = 3.9 KJ/K

69. Choose the correct option for the Joule-Thomson coefficient and its value for the heating:

A. $\left(\frac{\partial T}{\partial P}\right)_h$ and $\mu_J < 0$
B. $\left(\frac{\partial h}{\partial P}\right)_T$ and $\mu_J < 0$
C. $\left(\frac{\partial h}{\partial T}\right)_P$ and $\mu_J > 0$
D. $\left(\frac{\partial P}{\partial T}\right)_h$ and $\mu_J < 0$

Ans. A

Sol. Joule-Thomson coefficient is the slope of Isenthalpic curve on T-P diagram.

$$\mu_J = \left(\frac{\partial T}{\partial P}\right)_h$$

$\mu_J > 0$ for the cooling.

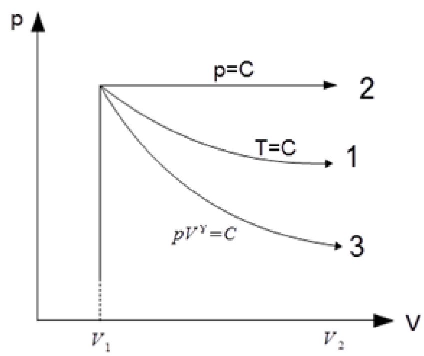
$\mu_J < 0$ for the Heating.

70. Maximum work by an expansion of a gas in a closed system is possible when process takes place at constant

A. pressure
B. temperature
C. volume
D. enthalpy

Ans. A

Sol. If a process $W_1$is purely isothermal (constant temperature), W_2 if purely isobaric (constant pressure) and W_3 adiabatic, at costant volume the work would be zero, then



Area under the curve in a p – V diagram is the work done.

$A_2 > A_1 > A_3$

Where,

A_1 = Area under curve 1

A_2 = Area under curve 2

A_3 = Area under curve 3

From the statement above, we have

W_2, W_1, W_3

71. Electricity is which kind of energy?

A. High grade energy B. Low grade energy

C. Neutral energy D. None

Ans. A

Sol. High grade energy: Mechanical or shaft work, electrical energy, kinetic energy etc.

Low grade energy: Heat or thermal energy, Heat derived from fossil fuels

72. Change in enthalpy in a closed system is equal to the heat transferred, if the reversible process takes place at constant

A. Temperature B. Internal energy

C. Pressure D. Entropy

Ans. C

Sol.

$$dQ = du + pdV$$

At constant pressure

$$pdV = d(pV)$$

$$\therefore \quad (dQ)_P = d(u + pV) = dh$$

Hence, heat transferred at constant pressure increases enthalpy of a system.

73. What will be the dryness fraction for liquid (m_1) and vapour (m_2) mixture?

A. $x = (m_1 + m_2)/m_1$ B. $x = (m_1 + m_2)/m_2$

C. $x = m_1/(m_1 + m_2)$ D. $x = m_2/(m_1 + m_2)$

Ans. D

Sol. Option D is correct other options are wrong.

Dryness fraction(x) is the ratio of mass of steam to the total mass (i.e., mass of steam +mass of water).

$X = M_2/(M_1 + M_2)$

74. In an internal combustion engine, during the compression stroke the heat rejected to the cooling water is 60kJ/kg and the work input is 110kJ/kg. Calculate the change in internal energy of the working fluid stating whether it is a gain or loss.

A. Loss in internal energy, - 70 kJ/kg B. Gain in internal energy, 70 kJ/kg

C. Loss in internal energy = - 50 kJ/kg D. Gain in internal energy = 50 kJ/kg

Ans. D

Sol. Heat rejected to the cooling water, Q = – 60 kJ/kg

(–ve sign since heat is rejected)

Work input, W = – 110 kJ/kg

(–ve sign since work is supplied to the system)

Using the relation, $Q = (u_2 - u_1) + W$

$-60 = (u_2 - u_1) - 110$

Or $u_2 - u_1 = -60 + 110 = 50$ kJ/kg

Hence, gain in internal energy = 50 kJ/kg

75. At triple point of a pure substance _____.

A. Liquid and vapour phase co-exist

B. Solid and vapour phase co-exist

C. Liquid and solid phase co-exist

D. Solid, Liquid and vapour phase co-exist.

Ans. D

Sol. The triple point is a line on the P – V diagram where all the three phases solid, liquid and gases exist in equilibrium. At a pressure below the triple point line, the substance cannot exist in liquid phase and the substance when heated, transforms from solid to vapours by absorbing the latent heat of sublimation from the surrounding.

76. Consider the following properties

1) Volume

2) Pressure

3) Enthalpy

4) Specific entropy

5) Temperature

6) Kinetic energy

Select the correct option which describes the listed properties as

(Intensive properties) (Extensive properties)

A. (3, 6 1) (2, 4, 5)

B. (1, 2, 3)(5 4, 6)

C. (2, 4, 5) (1, 3, 6)

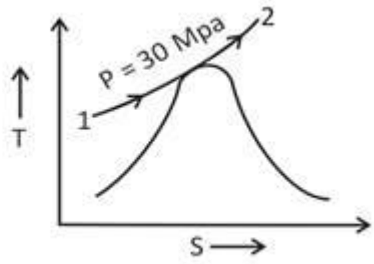
D. (1, 2, 5) (6, 3, 4)

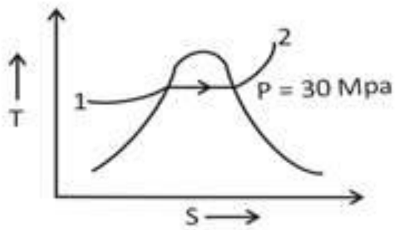
Ans. C

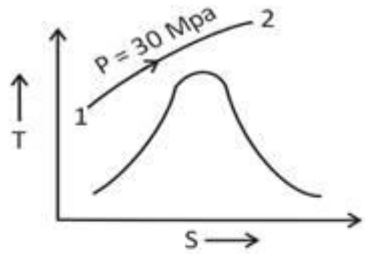
Sol. Intensive properties are mass independent properties, i.e. pressure, specific entropy, temperature

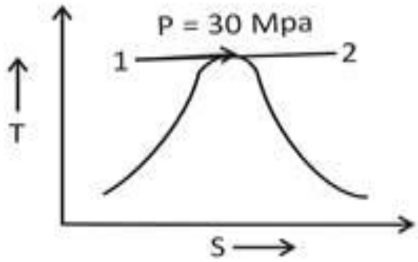
Extensive properties are mass dependent properties, i.e. volume, enthalpy, kinetic energy

77. The correct T – s diagram of Steam Rankine cycle with constant pressure (p = 30 Mpa) heat addition is given as

A.


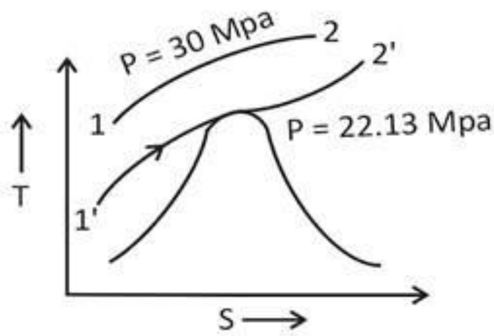
B.


C.


D.


Ans. C

Sol. For water Critical pressure is 22.12 Mpa so any heat addition line process in Rankine cycle above critical pressure has to be above critical point. Only option 'C' satisfies this condition.



78. Which law of thermodynamics will be violated, if the thermal efficiency of an engine becomes 100%?

A. Zeroth law

B. First law

C. Second law

D. Third law

Ans. C

Sol. 100% thermal efficiency of an engine means there is no heat rejection, whatever amount is supplied to the engine is converted into the work. It violates the second law of thermodynamics.

79. What is the amount of maximum work that can be extracted from a Carnot engine working between temperature 1000 K and 350 K if 4kJ heat is supplied to the engine?

A. 1.4kJ

B. 3.6kJ

C. 2.6kJ

D. Non of the above

Ans. C

Sol. Given,

Source temperature, T_H = 1000K

Sink Temperature T_L =350K

heat Supplied, Q_S = 4kJ

$$\eta = \frac{\text{work done}}{\text{Heat Supplied}} = 1 - \frac{T_L}{T_H}$$

$$\frac{W_{net}}{4} = 1 - \frac{350}{1000}$$

W_{net} = 2.6kJ

80. Three engines A, B and C operating on Carnot cycle use working substances as Argon, Oxygen and Air respectively. Which engine will have higher efficiency?

A. Engine A
B. Engine B
C. Engine C
D. All engines have same efficiency

Ans. D

Sol. Since efficiency depends only on temperature. Efficiency of Carnot engines depend upon the temperatures of the thermal reservoirs only, not on the working fluids.

81. Gibbs free energy is considered at which one of the following condition?

A. Isothermal, isochoric
B. Isobaric, isochoric
C. Isothermal, isobaric
D. None of these

Ans. C

Sol. Gibbs free energy is used to calculate the maximum of reversible work that may be performed by a thermodynamic system at constant temperature (isothermal) and constant pressure (isobaric)

82. A new temperature scale in degrees N is to be defined. The boiling and freezing on this scale are 400 °N and 100 °N respectively. What will be the reading on new scale corresponding to 80 °C?

A. 340 °N
B. 240 °N
C. 220 °N
D. 280 °N

Ans. A

Sol. The boiling and freezing points on new scale are 400 ° N and 100 °N i.e. range is 300 °N corresponding to 100 °C. Thus conversion equation is

°N = 100 + 3 × °C = 100+ 3 × 80 = 100 + 240 = 340 °N

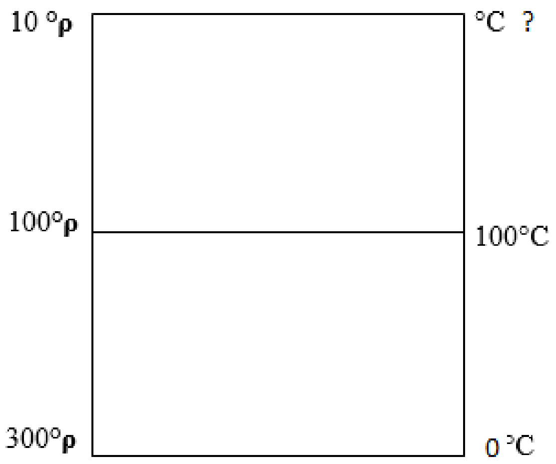
83. In a new temperature scale say °ρ, the boiling and freezing points of water at one atmosphere are 100 °ρ and 300 °ρ respectively. Correlate this scale with the Centigrade scale. The reading of 10 °ρ on the Centigrade scale is:

A. 150 °C
B. 145 °C
C. 120 °C
D. 150.5 °C

Ans. B

Sol. $\frac{10-300}{100-300} = \frac{C-0}{100-0}$

C = 145



84. A cylinder filled with 2 kg of oxygen(γ=1.4) is heated at constant pressure from 27°C to 127°C, the heat supplied is equal to

A. 201 kJ
B. 224 kJ
C. 105 kJ
D. 182 kJ

Ans. D

Sol. Given,

m = 2 kg oxygen

γ=1.4

T_1 = 27°C T_2 = 127°C

Q = mC_pdT

$C_p = \frac{\gamma R}{(\gamma - 1)}$

For oxygen,

$R = \frac{R_0}{M} = \frac{8314}{32} = 259.8$

$C_p = \frac{259.81 \times 1.4}{0.4} = 909.34 J/kgK$

Q = 2×909.34×(127-27) =181868.75 J

Q = 181.86kJ = 182kJ

85. The increase in pressure _____________.

A. lowers the boiling point of a liquid

B. raises the boiling point of a liquid

C. does not affect the boiling point of a liquid

D. has unpredictable effect on boiling point

Ans. B

Sol. liquid vapourises when molecules moves faster and far apart to each other but while increasing pressure, means applying an external force to hold molecules closer to each other. Hence, molecules will require more energy to overcome this resistance thus this increases boiling point of liquid

86. A vessel of volume 1 m^3 contains oxygen (molecular weight = 32) at P=1 bar and T = 74°C. The mass of oxygen in the vessel is (take universal gas constant as 8314 J/mol-k)

A. 40 kg
B. 3 kg
C. 1.2 kg
D. 1 kg

Ans. C

Sol. $PV = mRT$

$$m = \frac{PV}{RT}$$

$$R = \frac{8314}{Mol.wt.} = \frac{8314}{32} = 259.8 J / mol.k$$

$$M = \frac{10^5 \times 1}{259.8 \times (74 + 273)} = 1.2kg$$

87. Real expansion and compression processes have a degree of friction and this will

A. generate heat which is in effect a heat transfer
B. increase the entropy
C. make the final temperature bigger than it would otherwise be if it is a gas or superheated vapour
D. All of these

Ans. D

Sol. Real expansion and compression processes have a degree of friction and this will

- generate heat which is in effect a heat transfer.
- increase the entropy.
- make the final enthalpy bigger than it would otherwise be.
- make the final temperature bigger than it would otherwise be if it is a gas or superheated vapour

88. The property relation for enthalpy change, dh is ________.

A. Tds – pdv
B. Tds + vdp
C. Tds – vdp
D. Tds + pdv

Ans. B

Sol. T-ds equations are given by:

Tds = du + pdv

Tds = dh – vdp

dh = Tds + vdp

89. The continual motion of a movable device in absence of friction __________.

A. Violates first law of thermodynamics

B. Violates second law of thermodynamics

C. is PMM-II

D. is PMM-III

Ans. D

Sol. Machines of the third kind are those which completely eliminate friction, and therefore continue a motion forever due to inertia. But in practice, friction cannot be completely eliminated in any system.

90. When we obtain useful work during a process in which a finite system undergoes a change of state, when should that process terminate?

A. when the pressure of system equals the pressure of surroundings

B. when the temperature of system equals the temperature of surroundings

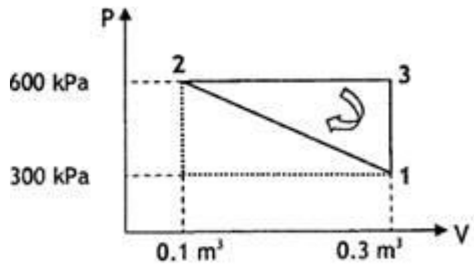
C. when the system has reached the dead state

D. all of the mentioned

Ans. D

Sol. Useful work is obtained when the final state is a dead state or in equilibrium with the surrounding state.

91. Find the total heat transfer (in kJ)in reversible cycle, if processes 1-2, 2-3 and 3-1 are carried using 0.5 kg of gas?



A. 65

B. 30

C. 70

D. 50

Ans. B

Sol. In the closed cycle

$\Sigma Q = \Sigma W$

ΣQ = Area of portion 1-2-3-1

$\Sigma Q = 0.5\ (0.3 - 0.1)\ (600 - 300)$

Total amount of heat transfer in the system will be $\Sigma Q = 30KJ$

92. Which of the following kind of devices complies with Clausius statement?

A. I. C. engine

B. Gas Turbines

C. Domestic refrigerator

D. None of the above

Ans. C

Sol. Clausius statement provides the concept of work absorbing device i.e. refrigerator, heat pumps

93. A 800-MW steam power plant, which is cooled by a nearby river, has a thermal efficiency of 40% Rate of heat transfer to the river water is _______ MW.

A. 1200 B. 1400

C. 1600 D. 1800

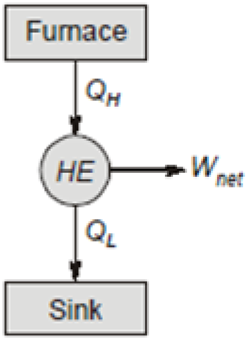
Ans. A

Sol. Given,

work output by Steam power plant = 800 MW,

thermal efficiency = 40%,

Rate of heat transfer to the river water (Sink) =



$$Q_H = \frac{W_{Net}}{\eta_{th}} = \frac{800}{0.4} = 2000 \text{ MW}$$

$$Q_1 = Q_H - W_{Net}$$

= 2000 – 800

= 1200 MW

94. The enthalpy of saturated water at triple point in a steam table is

A. zero B. slightly negative

C. slightly positive D. can't say

Ans. C

Sol. In steam table, the internal energy and entropy of saturated water at triple point (0.01°C) are chosen to be zero.

Enthalpy, h = u + pv

Due to "pv" terms, the enthalpy of saturated water at triple point will be slightly positive.

95. In an adiabatic process 4000 J of work is performed on a system. In the nonadiabatic process by which the system returns to its original state 1000J of heat is added to the system. What is the work done during non-adiabatic process?

A. + 5000 J B. - 5000 J

C. + 500 J D. - 500 J

Ans. A

Sol. $Q_{1-2} = U_2 - U_1 + W_{1-2}$

Or $0 = U_2 - U_1 - 4000$

or $U_2 - U_1 = + 4000$

$Q_{2-1} = U_1 - U_2 + W_{2-1}$

or $W_{2-1} = Q_{2-1} - (U_1 - U_2)$

$= 1000 + 4000 = 5000J$

Alternatively,

in a cyclic process,

$\Sigma Q = \Sigma W$

Therefore,

$0+1000=-4000 + W_{2-1}$

or $W_{2-1} = 5000$ J

96. Which one of the following is correct?

The cyclic integral of $\partial Q - \partial W$ for a cycle is

A. positive
B. negative
C. zero
D. unpredictable

Ans. C

Sol. This is the first law for a closed system undergoing a cycle.

97. Match List-I with List- II and choose the correct answer from the code given below

List- I

(Law of Thermodynamics)

A) First

B) Second

C) Third

D) Zeroth

List- II

(Introduces/ Defines)

1) Absolute zero temperature

2) Internal energy

3) temperature

4) Entropy

A. A-1, B-2, C-3, D-4
B. A-2, B-4, C-1, D-3
C. A-3, B-4, C-2, D-1
D. A-2, B-3, C-1, D-4

Ans. B

Sol. 1. Zeroth law introduces temperature measurement,

2. First law defines internal energy,

3. Second law defines the concept of entropy and

4. Third law states about impossibility to achieve absolute zero temperature.

98. Availability function for a closed system is given by _______.

A. u – pv – Ts
B. u + pv + Ts
C. u – pv + Ts
D. u + pv – Ts

Ans. D

Sol. Availability (A) = $W_{useful} - P_0(V_0 - V_1)$

Consider a system which interacts with the ambient at T_0.

Then, $W_{max} = (U_1 - U_0) - T_0(S_1 - S_0)$

99. Outside atmospheric air at 35°C is cooled by an air-conditioner upto 15°C with a mass flow rate of 1 kg/s. what will be the amount of power needed to operate this air-conditioner(Assume air-conditioner to be a reversible refrigerator)?

A. 3.5 kW
B. 20.08 kW
C. 1.4 kW
D. 4.9 kW

Ans. C

Sol. Consider the cooling of air which needs a heat transfer as

Qair = mC_pdT = 1 × 1.004 × (35-15) = 20.08 kW

Assume Carnot cycle refrigerator,

$$COP = \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L} = \frac{T_L}{T_H - T_L}$$

$$COP = \frac{(273+15)}{(273+35)-(273+15)}$$

= 14.4

Thus the amount of power needed to operate the air conditioner is,

$$W = \frac{Q_L}{COP} = \frac{20.08}{14.4} = 1.4kW$$

100. A heat engine is supplied with 300KJ/s of heat at a constant fixed temperature of 327°C; the heat is rejected at 27°C, the cycle is reversible, then the amount of heat rejected is

A. 250 KJ/s
B. 200 KJ/s
C. 180 KJ/s
D. 150 KJ/s

Ans. D

Sol. For reversible cycle:

$$\oint \frac{\delta Q}{T} = 0$$

$$\frac{Q_1}{T_1} - \frac{Q_2}{T_2} = 0$$

$$\frac{300}{600} - \frac{Q_2}{300} = 0$$

Q_2 = 150 KJ/s

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