Bihar Public Service Commission
Main Examination, 2019
Assistant Engineer

General Paper-V
Mechanical Engineering

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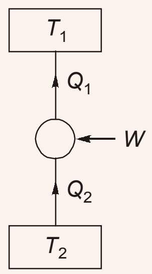
MECHANICAL ENGINEERING (PAPER-V)

Q.1 An ideal refrigerator is operating between a condenser temperature of 37°C and an evaporator temperature of –3°C. If the machine is functioning as a heat pump, its coefficient of performance (COP) will be

(A) 6.0 (B) 6.75
(C) 7.0 (D) 7.75

Ans. (D)

COP of heat pump:



$$\text{COP} = \frac{T_1}{T_1 - T_2}$$

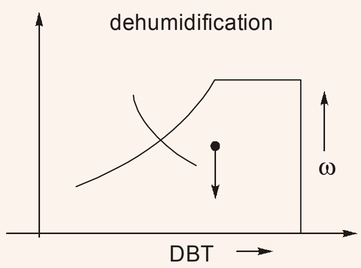
$$\text{COP} = \frac{37+273}{37-(-3)} = \frac{310}{40} = 7.75$$

End of Solution

Q.2 On a psychrometric chart, what does a vertical downward line represent?

(A) Adiabatic saturation (B) Sensible cooling
(C) Dehumidification (D) Humidification

Ans. (C)



End of Solution

Q.3 The knocking tendency in CI engine increases with
(A) decrease of compression ratio
(B) increase in coolant water temperature
(C) increase of compression ratio
(D) increase of temperature of inlet air

Ans. (A)

End of Solution

Q.4 The specific fuel consumption per kW-hr for diesel engine is very close to
(A) 0.4 kg/kW-hr
(B) 0.33 kg/kW-hr
(C) 0.27 kg/kW-hr
(D) 0.47 kg/kW-hr

Ans. (C)

End of Solution

Q.5 Equivalence evaporation is defined as
(A) the ratio of heat actually used in producing stream to the heat liberated in the furnace
(B) the amount of water evaporated in kg per kg of coal burnt
(C) evaporation of water from and at 100°C into dry saturated steam
(D) evaporation of 15.653 kg of water per hour from and at 100°C

Ans. (B)
It is defined as amount of water evaporated in kg per kg of energy supplied [or per kg of fuel burnt].

End of Solution

Q.6 High positive incidence in an axial compressor bladed leads to
(A) suppression of separation of flow on the blade
(B) choking of the flow
(C) separation of flow on the suction side of the blade
(D) separation of flow on the pressure side of the blade

Ans. (C)
Stalling is the separation of flow from the blade surface. At high incidence, flow separation occurs on the suction side of the blades which is referred as positive stalling.

End of Solution

Q.7 If K is the ratio of the rate of production of neutrons to the rate of loss of neutrons, the reactor is called a critical reactor, when
(A) $K = 0$
(B) $0 < K < 1$
(C) $K = 1$
(D) $K > 1$

Ans. (C)

End of Solution

Q.8 The volumetric efficiency of a well-designed SI engine lies in the range of
(A) 40%–50%
(B) 51%–60%
(C) 61%–70%
(D) 71%–90%

Ans. (D)

End of Solution

Q.9 A centrifugal compressor is used for which of the following?
(A) High pressure ratio and low mass flow
(B) Low pressure ratio and low mass flow
(C) High pressure ratio and high mass flow
(D) Low pressure ratio and high mass flow

Ans. (D)

End of Solution

Q.10 The free convection heat transfer is significantly affected by
(A) Reynolds number
(B) Grashof number
(C) Prandtl number
(D) Stanton number

Ans. (B)

$$\text{Grashof number} = \frac{\text{Buoyancy force}}{\text{Viscous force}}$$

Buoyant force occurs due to free convection.

End of Solution

Q.11 The thermal radiations occur in the portion of electromagnetic spectrum between the wavelengths
(A) 10^{-2} micron to 10^{-4} micron
(B) 10^{-1} micron to 10^{-2} micron
(C) 0.1 micron to 10^{2} micron
(D) 10^{2} micron onwards

Ans. (C)

End of Solution

Q.12 The change in entropy is zero during
(A) hyperbolic process
(B) constant pressure process
(C) adiabatic process
(D) polytropic process

Ans. (C)
For reversible adiabatic process change in entropy is zero, so best option is (C).

End of Solution

Q.13 Joule-Thomson coefficient is given as

(A) $\left(\frac{\partial T}{\partial G}\right)_P$ (B) $\left(\frac{\partial T}{\partial P}\right)_h$

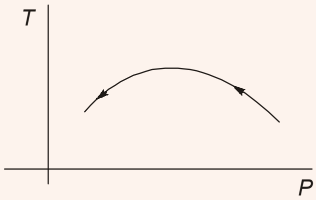
(C) $\left(\frac{\partial U}{\partial T}\right)_P$ (D) $\left(\frac{\partial P}{\partial T}\right)_h$

Ans. (B)

Joule-Thomson coefficient is

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

For constant enthalpy process.



End of Solution

Q.14 If x is the distance from the leading edge of a plate, then the thickness of laminar boundary layer varies as

(A) $\frac{1}{x}$ (B) $x^{4/5}$

(C) $x^{1/2}$ (D) x^2

Ans. (C)

Laminar thermal boundary layer

$$\delta = \frac{5x}{\sqrt{\text{Re}_x}} \propto \frac{x}{\sqrt{x}} \propto \sqrt{x}$$

End of Solution

Q.15 Shielding in a nuclear reactor is generally done to protect against

(A) excess electrons (B) X-rays

(C) α-and β-rays (D) neutron and gamma rays

Ans. (D)

End of Solution

Q.16 Reynolds analogy states that

(A) $St = \frac{C_{fx}}{4}$ (B) $St = \frac{C_{fx}}{2}$

(C) $St = \sqrt{C_{fx}}$ (D) $St = 2C_{fx}$

Ans. (B)

End of Solution

Q.17 The air-fuel ratio for a gas turbine is generally kept closer to

(A) 20 : 1
(B) 30 : 1
(C) 40 : 1
(D) 60 : 1

Ans. (D)

End of Solution

Q.18 The volumetric efficiency of a reciprocating compressor

(A) increases with increasing clearance ratio
(B) increases with increase in compression index
(C) does not change with change in clearance ratio and pressure ratio
(D) decreases both with increasing clearance ratio and pressure ratio

Ans. (D)

Volumetric efficiency of reciprocating compressor is

$$\eta_v = 1 + c - c\left(\frac{P_2}{P_1}\right)^{\frac{1}{n_e}} = 1 - c\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n_e}} - 1\right]$$

$$\text{if } c\uparrow,\ \frac{P_2}{P_1}\uparrow \Rightarrow \eta_v \downarrow$$

End of Solution

Q.19 The work ratio in a simple gas turbine plant in terms of pressure ratio r_p is

(A) $1 - \frac{T_3}{T_1}(r_p)^{\frac{\gamma-1}{\gamma}}$
(B) $1 - \frac{T_1}{T_3}(r_p)^{\frac{\gamma-1}{\gamma}}$
(C) $1 - \frac{T_1}{T_3}(r_p)^{\frac{\gamma}{\gamma-1}}$
(D) $1 - \frac{T_1}{T_3}(r_p)^{\frac{1}{\gamma}}$

Ans. (B)

$$\text{Work ratio} = \frac{W_{net}}{W_T} = 1 - \frac{T_1}{T_3}(r_p)^{\frac{\gamma-1}{\gamma}}$$

End of Solution

Q.20 A boiling water reactor uses which of the following as fuel?

(A) U^{234}
(B) U^{235}
(C) Enriched uranium
(D) Plutonium

Ans. (C)

End of Solution

Q.21 In a gas turbine cycle, the turbine output is 600 kJ/kg, the compressor work is 400 kJ/kg and the heat supplied is 1000 kJ/kg. The thermal efficiency of the cycle is

(A) 20%
(B) 40%
(C) 60%
(D) 80%

Ans. (A)

$$\text{Thermal efficiency, } \eta = \frac{\text{Net work done}}{\text{Heat supplied}}$$

$$= \frac{600-400}{1000}\times 100 = 20\%$$

End of Solution

Q.22 Clausius-Clapeyron equation gives the slope of the curve in

(A) p-v diagram
(B) p-h diagram
(C) p-T diagram
(D) T-S diagram

Ans. (C)

Clausius – Clapeyron equation

$$\frac{\partial P}{\partial T} = \frac{h_{fg}\times P}{R^2}$$

it gives slope of P-T curve.

End of Solution

Q.23 An ideal gas of mass m and temperature T_1 undergoes a reversible isothermal process from an initial pressure P_1 to final pressure P_2. The heat loss during the process is Q. The entropy change ΔS of the gas is

(A) $mR\ln\left(\frac{P_2}{P_1}\right)$
(B) $mR\ln\left(\frac{P_1}{P_2}\right)$
(C) $mR\ln\left(\frac{P_2}{P_1}\right)-\frac{Q}{T_1}$
(D) zero

Ans. (B)

Entropy change for a gas for any process if two states are known.

$$\Delta S = mC_p\ln\frac{T_2}{T_1} - mR\ln\frac{P_2}{P_1}$$

$$\Delta S = -mR\ln\frac{P_2}{P_1} = mR\ln\frac{P_1}{P_2}$$

[For constant temperature process]

End of Solution

Q.24 In a reversible isothermal expansion process, the fluid expands from 10 bar and 2 m^3 to 2 bar and 10 m^3. During this expansion process, 100 kW of heat is supplied. Then the work done during the process is

(A) 33.3 kW
(B) 80 kW
(C) 100 kW
(D) 20 kW

Ans. (C)

Assuming ideal gas and reversible isothermal process

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

$$\Delta Q = \Delta W$$

For isothermal and ideal gas $\Delta U = F(T)$

As heat transfer is 100 kW is given, work will also be equal to 100 kW.

End of Solution

Q.25 The head loss in a sudden expansion from 6 cm diameter pipe to 12 cm diameter pipe, in terms of velocity V_1 in the smaller diameter pipe is

(A) $\frac{3}{16}\frac{V_1^2}{2g}$
(B) $\frac{5}{16}\frac{V_1^2}{2g}$
(C) $\frac{7}{16}\frac{V_1^2}{2g}$
(D) $\frac{9}{16}\frac{V_1^2}{2g}$

Ans. (D)

Head loss in a sudden expansion

$$h_L = \frac{(V_1 - V_2)^2}{2g} = \frac{V_1^2}{2g}\left(1 - \frac{V_2}{V_1}\right)^2$$

$$= \frac{V_1^2}{2g}\left(1 - \frac{d_1^2}{d_2^2}\right)^2 = \frac{V_1^2}{2g}\left(1 - \left(\frac{6}{12}\right)^2\right)^2$$

$$= \frac{9}{16}\frac{V_1^2}{2g}$$

End of Solution

Q.26 Thermal conductivity through walls of a cylinder of inner and outer radii r_1 and r_2, respectively is inversely proportional to

(A) $(r_2 - r_1)$
(B) $\frac{1}{r_2 - r_1}$
(C) $\ln\left(\frac{r_2}{r_1}\right)$
(D) $\frac{1}{\ln\left(\frac{r_2}{r_1}\right)}$

Ans. (C)

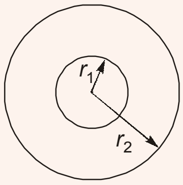
Actually thermal conductivity is a material property and it does not depends on the dimensions.

But considering the given question heat conduction must have been asked.

$$Q = -kA\frac{dT}{dx}$$

$$\Rightarrow \quad Q = -k2\pi rl\frac{dT}{dr}$$

$$\Rightarrow \quad \int Q\frac{dr}{r} = \int -2\pi kl dT$$



$$\Rightarrow \quad Q\ln\left(\frac{r_2}{r_1}\right) = -2\pi kl(\Delta T)$$

$$\Rightarrow \quad Q = \frac{-2\pi kl\Delta T}{\ln\left(\frac{r_2}{r_1}\right)}$$

End of Solution

Q.27 The maximum work output from two finite bodies-one at temperature T_1 and the other at temperature T_2 is

(A) $W_{max} = C_p\left(\sqrt{T_1} - \sqrt{T_2}\right)^2$

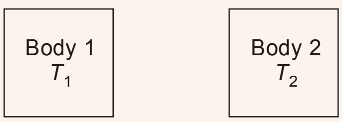
(B) $W_{max} = C_p\left(\sqrt{T_1} + \sqrt{T_2}\right)^2$

(C) $W_{max} = C_p\left(\sqrt{T_1}\sqrt{T_2}\right)^{1/2}$

(D) $W_{max} = \frac{1}{2}C_p\left(\sqrt{T_1} - \sqrt{T_2}\right)^2$

Ans. (A)

Maximum work output will be obtained when there will be no irreversibility.



We can extract work till both bodies reaches at same temperature let it be T_f.

Entropy change for body 1 $= C_p\ln\frac{T_f}{T_1}$

Entropy change for body 2 = $C_p \ln \frac{T_f}{T_2}$

For reversible process entropy change is zero, so

$$C_p \ln \frac{T_f}{T_1} + C_p \ln \frac{T_f}{T_2} = 0$$

$$\Rightarrow \quad T_f = \sqrt{T_1 T_2}$$

work done = (Energy given by body 1) – (Energy absorbed by body 2)

$$= C_p(T_1 - T_f) - C_p(T_f - T_2)$$

$$= C_p(T_1 + T_2 - 2T_f)$$

$$= C_p(T_1 + T_2 - 2\sqrt{T_1 T_2}) = C_p\left(\sqrt{T_1} - \sqrt{T_2}\right)^2$$

Note we have assumed $T_1 > T_2$, we will get same answer for $T_2 > T_1$ also.

End of Solution

Q.28 Most of the gases exhibit drop in temperature upon expansion. However, this may not be true in case of

(A) carbon dioxide
(B) oxygen
(C) hydrogen
(D) helium

Ans. (D)

End of Solution

Q.29 If the dryness fraction of a sample by throttling calorimeter is 0.8 and that by separating calorimeter is also 0.8, then the actual dryness fraction of sample will be taken as

(A) 0.8
(B) $\sqrt{0.8}$
(C) 0.64
(D) 0.5

Ans. (A)

End of Solution

Q.30 In a simple impulse turbine, the nozzle angle at the entrance is 30°. For the maximum diagram efficiency, what is the blade speed ratio?

(A) 0.259
(B) 0.75
(C) 0.3
(D) 0.433

Ans. (D)

Given nozzle angle, $\alpha = 30°$

For maximum efficiency,

blade speed ratio, $\frac{u}{V} = \frac{\cos\alpha}{2} = \frac{\cos 30°}{2} = 0.433$

End of Solution

Q.31 What is the value of shape factor for two infinite parallel surfaces separated by a distance x?

(A) 0
(B) ∞
(C) 1
(D) x

Ans. (C)

For infinite parallel surfaces separated by some distance shape factor is one as total energy leaving one surface reaches other surface.

End of Solution

Q.32 An engine operates between temperature limits of 900 K and T_2 and the other engine operates between T_2 and 400 K. For both engines to be equally efficient, T_2 should be equal to

(A) 600 K
(B) 625 K
(C) 650 K
(D) 700 K

Ans. (A)

$$\text{Efficiency of first engine} = 1 - \frac{T_2}{900}$$

$$\text{Efficiency of second engine} = 1 - \frac{400}{T_2}$$

For both to be equally efficient

$$1 - \frac{T_2}{900} = 1 - \frac{400}{T_2}$$

$$\Rightarrow \quad T_2 = 600$$

End of Solution

Q.33 Which one of the following parameters is significant to ascertain chemical equilibrium of a system?

(A) Clapeyron equation
(B) Maxwell relations
(C) Gibbs' function
(D) Helmholtz function

Ans. (C)

End of Solution

Q.34 If $\psi = x^2 - y^2$ is the stream function in a two-dimensional flow field, then the magnitude of velocity vector at point (1, 1) would be

(A) zero
(B) $2\sqrt{2}$
(C) 4
(D) 8

Ans. (B)

Given

$$\psi = x^2 - y^2$$

$$u = \frac{-d\psi}{dy} = 2y = 2 \qquad \text{(at (1, 1))}$$

$$v = \frac{d\psi}{dx} = 2x = 2 \qquad \text{(at (1, 1))}$$

$$|V| = \sqrt{u^2 + v^2} = 2\sqrt{2}$$

End of Solution

Q.35 In a two-stage reciprocating air compressor, the suction and delivery pressure are 1 bar and 4 bar respectively. For the maximum efficiency the intercooler pressure is

(A) 1.5 bar
(B) 2.5 bar
(C) 2.0 bar
(D) 3.0 bar

Ans. (C)

For maximum efficiency

$$P_i = \sqrt{P_1 P_2} = \sqrt{1 \times 4} = 2 \text{ bar}$$

End of Solution

Q.36 In a vapour absorption refrigerator, heat is rejected in

(A) condenser only
(B) absorber only
(C) generator only
(D) condenser and absorber

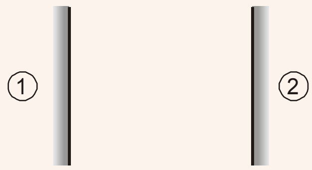
Ans. (D)

End of Solution

Q.37 Two long parallel plates of same emissivity 0.5 are maintained at different temperatures and have radiation heat exchange between them. A radiation shield of emissivity 0.25 placed in the middle will reduce radiation heat exchange to

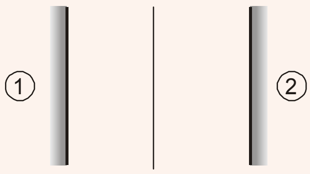
(A) 1
(B) $\frac{1}{4}$
(C) $\frac{3}{10}$
(D) $\frac{3}{5}$

Ans. (C)



$\in_1 = 0.5 \qquad \in_2 = 0.5$

$$Q_1 = \frac{\sigma A(T_1^4 - T_2^4)}{\left(\frac{1}{\in_1} + \frac{1}{\in_2} - 1\right)} = \frac{\sigma A(T_1^4 - T_2^4)}{3}$$



$\in_2 = 0.25$

$$\Rightarrow \qquad Q_2 = \frac{\sigma A(T_1^4 - T_2^4)}{\frac{1-\in_1}{\in_1} + 1 + \left(\frac{1-\in_2}{\in_2}\right)2 + 1 + \frac{1-\in_1}{\in_1}}$$

$$\Rightarrow \qquad Q_2 = \frac{\sigma A(T_1^4 - T_2^4)}{10}$$

$$\frac{Q_2}{Q_1} = \frac{3}{10}$$

End of Solution

Q.38 In a nozzle designed for the maximum discharge conditions, the flow velocity in the convergent section of the nozzle

(A) is sonic
(B) is subsonic
(C) is supersonic
(D) depends upon the initial pressure and condition of steam

Ans. (B)

End of Solution

Q.39 For steady, fully developed flow inside a straight pipe of diameter D, neglecting gravity effects, the pressure drop ΔP over a length L and the wall shear stress τ_W are related by

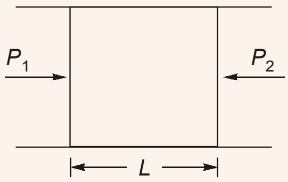
(A) $\tau_W = \frac{\Delta PD}{4L}$

(B) $\tau_W = \frac{\Delta PD^2}{4L^2}$

(C) $\tau_W = \frac{\Delta PD}{2L}$

(D) $\tau_W = \frac{4\Delta PL}{D}$

Ans. (A)



Considering equilibrium of a section of length L,

$$\tau_W \times \pi DL = \Delta P \frac{\pi D^2}{4}$$

$$\Rightarrow \quad \tau_W = \frac{\Delta PD}{4L}$$

End of Solution

Q.40 In order to have the maximum power from a Pelton turbine, the bucket speed must be

(A) equal to the jet speed
(B) equal to half of jet speed
(C) equal to twice the jet speed
(D) independent of the jet speed

Ans. (B)

End of Solution

Q.41 Stalling of blades in an axial flow compressor is the phenomenon of

(A) airstream blocking the passage
(B) motion of air at sonic velocity
(C) unsteady, periodic and reversible flow
(D) airstream not able to follow the blade contour

Ans. (D)

End of Solution

Q.42 During chemical dehumidification process of air
(A) dry-bulb temperature and specific humidity decrease
(B) dry-bulb temperature increases and specific humidity decreases
(C) dry-bulb temperature decreases and specific humidity increases
(D) dry-bulb temperature and specific humidity increase

Ans. (B)

In chemical de-humidification process temperature of air increases as its moisture content decreases.

End of Solution

Q.43 The latent heat load in an auditorium is 25% of sensible heat load. The value of sensible heat factor is then equal to
(A) 0.25 (B) 0.5
(C) 0.8 (D) 1.0

Ans. (C)

Given, LH = 0.25 SH

$$\text{SHF} = \frac{SH}{SH + LH} = \frac{1}{1.25} = 0.8$$

End of Solution

Q.44 Which of the following parameters remains constant during a sensible cooling or heating process?
(A) Dry-bulb temperature (B) Wet-bulb temperature
(C) Humidity ratio (D) Relative humidity

Ans. (C)

End of Solution

Q.45 In order to have a low by-pass factor of cooling coil, the fin spacing and the number of tubes rows should be respectively
(A) wide apart and high (B) wide apart and low
(C) close and low (D) close and high

Ans. (D)

To keep low by-pass factor, we need to maximize heat transfer. Hence, we need to keep fins closely and increase number of tubes rows.

End of Solution

Q.46 The emissive power of a black body is P. If its absolute temperature is doubled, the emissive power becomes

(A) 2P (B) 4P

(C) 8P (D) 16P

Ans. (D)

As emissive power, $E \propto T^4$

So, $$\frac{E_2}{E_1} = \frac{(2T)^4}{T^4} = 16$$

End of Solution

Q.47 An increase in the mean effective pressure of a diesel engine with fixed compression ratio can be obtained with increase in

(A) speed of the engine (B) charge density

(C) cut-off ratio (D) back pressure

Ans. (C)

By increasing the cut-off ratio, the work done increases and hence mean effective pressure increases.

End of Solution

Q.48 The order of values of thermal efficiency of Otto, diesel and dual cycles, when they have the same maximum pressure and heat input, is given by

(A) $\eta_{Otto} > \eta_{diesel} > \eta_{dual}$ (B) $\eta_{Otto} > \eta_{dual} > \eta_{diesel}$

(C) $\eta_{diesel} > \eta_{dual} > \eta_{Otto}$ (D) $\eta_{diesel} > \eta_{Otto} > \eta_{dual}$

Ans. (C)

End of Solution

Q.49 Shock effect in the nozzle generally occurs in

(A) converging section (B) throat

(C) diverging section (D) exit

Ans. (C)

End of Solution

Q.50 The normal operating range of air/fuel ratio for a CI engine with diesel fuel is

(A) 8 : 1 to 12 : 1 (B) 12 : 1 to 22 : 1

(C) 20 : 1 to 30 : 1 (D) 18 : 1 to 70 : 1

Ans. (D)

End of Solution

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