BYJU'S EXAM PREP

UPPSC

Mechanical Engineering

AE Paper-2 Mega Mock

(January 7th - January 8th 2022)

Questions & Solutions

1. In compressor of a Refrigerator, air enters in the axial flow compressor & leaves the compressor axially. Calculate the degree of reaction, if the component of air responsible for whirl is leaving the compressor at one-third the average blade velocity of rotor if the flow velocity at inlet and outlet remain same.

    A. 0.75
    B. 0.833

    C. 0.5
    D. 0.333

Ans. B

Sol. Given,

$$V_{w2} = \frac{1}{3}u_2$$

$V_{f1} = V_{f2}$

Since,

Degree of Reaction:

$$R = \frac{\text{Rise of enthalpy in rotor}}{\text{Rise of enthalpy in stage}} = 1 - \frac{\frac{V_{w2}^2 - V_{w1}^2}{2} + \frac{v_{f2}^2 - v_{f1}^2}{2}}{V_{w2}u_2 - V_{w1}u_1}$$

$V_{w1} = 0$, $v_{f1} = v_{f2}$

$$R = 1 - \frac{V_{w2}^2}{2V_{w2}u_2} = 1 - \frac{V_{w2}}{2u_2}$$

$$R = 1 - \frac{V_{w2}}{2u_2} = 1 - \frac{\frac{1}{3}u_2}{2u_2} = 0.8333$$

2. Which of the following parameter remain constant during Morse test of the IC engine?

    A. Friction power
    B. Load on the dynamometer

    C. Break power
    D. Indicated power

Ans. A

Sol. The Morse test is used to obtain the Indicated Power (IP) of a Multi-cylinder Engine. In it the load on the dynamometer is adjusted so as maintain constant speed and so frictional power (FP). FP is independent of load and proportional to engine speed.

3. Which of the following types of pumps is suitable for pumping viscous fluids?

    A. Centrifugal pump
    B. Reciprocating pump

    C. Air lift pump
    D. Screw pump

Ans. D

Sol.

o   A screw pump is a type of rotary pump which is equipped with screws that mesh together and rotate within a cylindrical cavity or liner.

o   Most of these applications deal with high viscous fluids such as oil, asphalt, multi-phase fluid, which means there is liquid and vapor mixed together in the fluid stream.

4. Which of the following is a measure to increase collection efficiency?

    A. Selective surface coating
    B. Decreasing space between corners

    C. Increasing fluid inlet temperature
    D. All of these

Ans. A

Sol. ⇒ Selective surface coating is used to increase collection efficiency.

⇒ Selective coatings used to increase radiation losses constitute a special group: such coatings absorb solar radiation weakly and have a high emissivity.

5. A diesel engine has a compression ratio of 21 and cut-off takes place at 8% of the stroke. What is the cut – off ratio ?

A. 1.2   B. 2.2

C. 1.6   D. 2.6

Ans. D

Sol. Given:

compression ratio, r_k = 21

cut off takes place = 8% of(V_1 - V_2)

$$r_c - 1 = \frac{\% p}{100}\left(r_k - 1\right)$$

$$r_c - 1 = \frac{8}{100}(21 - 1)$$

r_c = 2.6

6. For a plate of length L, an average value of Nusselt number for fully developed laminar flow is given by_____.

A. Nu = 0.664 (Re) $^{0.4}$ (Pr) $^{0.54}$

B. Nu = 0.0234 (Re) $^{0.5}$ (Pr) $^{0.74}$

C. Nu = 0.664 (Re) $^{0.5}$ (Pr) $^{0.27}$

D. Nu = 0.664 (Re) $^{0.5}$ (Pr) $^{0.33}$

Ans. D

Sol. For a plate of length L,

an average value of Nusselt number for fully developed laminar flow is given by,

Nu = 0.664 (Re) $^{0.5}$ (Pr) $^{0.33}$

7. Stanton number is given by _____.

A. Nu × Re × Pr

B. $\dfrac{Nu}{Re \times Pr}$

C. $\dfrac{Nu \times Re}{Pr}$

D. $\dfrac{Re \times Pr}{Nu}$

Ans. B

Sol. The Stanton number, St, is a dimensionless number that measures the ratio of heat transferred into a fluid to the thermal capacity of the fluid.

$$\text{Stanton No.} = \frac{Nu}{Re \times Pr} = \frac{h}{\rho v c_p}$$

8. For constant maximum pressure and heat input, the air standard efficiency of power cycle is in the order.

A. Diesel cycle>Dual cycle>Otto cycle

B. Otto cycle>Diesel cycle>Dual cycle

C. Dual cycle>Otto cycle>Diesel cycle

D. Diesel cycle>Otto cycle>Dual cycle

Ans. A

Sol. For same maximum pressure and heat input, efficiencies vary in this order:

Diesel cycle> Dual cycle>Otto cycle

9. In vapour compression refrigeration system, refrigeration effect is 40 kJ/kg and COP of the system is 4. Find heat rejected in the condenser.

A. 40 kJ/kg   B. 50 kJ/kg

C. 60 kJ/kg   D. 70 kJ/kg

Ans. B

Sol. COP = (Refrigeration effect)/(Work input)

4 = 40/ (Work input)

Work input = 10 kJ/kg

Heat rejected in the condenser = Refrigeration effect + Work input

= 40 + 10

= 50 kJ/kg

10. Constant pressure lines in h – s diagram (Mollier chart) in superheated region are of

A. Converging nature   B. Diverging nature

C. Straight line   D. None of these

Ans. B

Sol. From T- ds relationship

$$Tds = dh - vdP$$

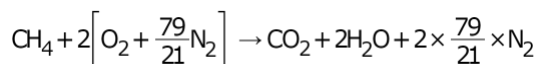For constant pressure lines, P = Const.

$$\left(\frac{dh}{ds}\right)_P = T$$

So, constant pressure lines in superheated region are of diverging nature.

11. Calculate the air-fuel ratio on molar basis that could come out, inside an Oil marketing R&D lab, Methane [CH_4] is made to undergo combustion with the stoichiometric quantity of air.

A. 17.16 : 1   B. 12.3 : 1

C. 4 : 1   D. 9.523 : 1

Ans. D

Sol.

$$CH_4 + 2\left[O_2 + \frac{79}{21}N_2\right] \rightarrow CO_2 + 2H_2O + 2 \times \frac{79}{21} \times N_2$$

Air moles $= 2 \times \left[1 + \dfrac{79}{21}\right] = 9.523$

Fule mole $= 1$

So A/F ratio $= \dfrac{9.523}{1}$

12. Which of the following refrigerant is commonly used in domestic refrigerator?

   A. Ammonia
   B. Carbon-dioxide
   C. Air
   D. Freon-12

Ans. D

Sol. R-12 is a highly versatile refrigerant that is used for wide range of refrigeration and air conditioning applications though in many air conditioning applications it is now replaced by R22 refrigerant. Refrigerant R12 is used in domestic refrigerators and freezers, liquid chillers, dehumidifiers, ice makers, water coolers, water fountains and transport refrigeration. The wide range of applications of the refrigerant is due to its safe properties.

13. A pelton wheel is having a mean bucket diameter of 1 m and is running at 1000 rpm. The net head on the pelton wheel is 700 m. If the discharge through nozzle is 0.1 m³/s, find power (in kW) available at nozzle.

   A. 398.23
   B. 987.73
   C. 686.70
   D. 899.65

Ans. C

Sol. We know that,

Power available at nozzle is given by equation,

$$W.P. = \dfrac{\rho g Q H}{10^3}$$

$$= \dfrac{10^3 \times 9.81 \times 0.1 \times 700}{10^3} = 686.7 \text{ kW}$$

14. Work ratio obtained in a Brayton cycle is 0.64. What is the back work ratio for this cycle?

   A. 0.64
   B. 0.36
   C. 0.6
   D. 1

Ans. B

Sol. Work ratio + Back work ratio = 1

   Work ratio = net work/Positive work

   Back work ratio = negative work/Positive work

   Back work ratio = 1-Work ratio

   $\qquad = 1- 0.64$

   $\qquad = 0.36$

15. Compression ratio of diesel engine varies from ____.

   A. 6 to 10
   B. 10 to 15
   C. 16 to 20
   D. 25 to 40

Ans. C

Sol.

- Diesel engine compression ratio is high and it varies from 16 to 20.
- Due to high compression ratio the diesel engine are bulky than the petrol engine which have less compression engine.

16. Which of the following quantities is not the property of the system_____?

    A. Pressure   B. Temperature

    C. Density   D. Heat

Ans. D

Sol.

- Every system has certain characteristics by which its physical condition may be described. Such characteristics are called properties of the system.
- Since heat transfer is the path function hence it is not the property of the system.

17. What is the main purpose of supercharging the engine _____?

    A. To reduce the mass of the engine per brake power.

    B. To reduce specific fuel consumption, in turbocharging

    C. To increase mechanical efficiency

    D. All of the above.

Ans. D

Sol. • Supercharging is the process of supplying the intake air at a density greater than the density of surrounding atmosphere.

    Purpose:

    • To improve engine power output i.e., mechanical efficiency.

    • Reduced specific fuel consumption, in turbocharging.

    • To reduce the mass of the engine per brake power.

18. Dilatant fluids are those for which_____.

    A. Dynamic viscosity increases as the rate of shear increases.

    B. Dynamic viscosity decreases as the rate of shear increases.

    C. Dynamic viscosity increases with time for which shearing force applied.

    D. Dynamic viscosity decreases with time for which shearing force applied.

Ans. A

Sol.

- Dilatent fluid: Dynamic viscosity increases as the rate shear increases.
- Pseudoplastic fluid: Dynamic viscosity decreases as the rate of shear increases.
- Thixotropic fluid: Dynamic viscosity decreases with time for which shearing force applied.
- Rheopectic fluid: Dynamic viscosity increases with time for which shearing force applied.

19. The surface tension of fluid in contact with air at 25℃ is 0.2 N/m. The pressure inside a droplet is to be 0.08 N/cm^2 greater than outside pressure. Determine the diameter of the droplet.

A. 1 mm   B. 10 mm

C. 100 mm   D. 1000 mm

Ans. A

Sol. Given,

We know that,

$$\Delta P = \frac{4\sigma}{d} \Rightarrow 800 = \frac{4 \times 0.2}{d}$$

$$d = 1 \times 10^{-3} m$$

$$d = 1mm$$

20. The available wind power in wind turbines increase with _____.

A. Decrease in rotor diameter   B. Increase in rotor diameter

C. Decrease in wind velocity   D. Decrease in air density

Ans. B

Sol. The wind power is given by:

$$\text{Power(P)} = \frac{1}{2}\rho AV^3$$

Where:

ρ = air density

$A = \pi r^2$ (Area of rotor) & r is radius of rotor.

V = wind speed

The available wind power in wind turbines increase with increase in rotor diameter.

21. For a boundary layer, the shape factor (H) is defined as _____.

A. $\dfrac{\delta}{\theta}$ B. $\dfrac{\delta^*}{\theta}$

C. $\dfrac{\theta}{\delta}$ D. $\dfrac{\theta}{\delta^*}$

Ans. B

Sol. Where δ^* is displacement thickness, δ = boundary layer thickness and θ is momentum thickness.

Shape factor (H) = $\dfrac{\text{Displacement thickness}(\delta^*)}{\text{Momentum thickness}(\theta)}$

• H is always greater than one.

22. Loss of head due to the sudden expansion of pipe is_____.

A. $\dfrac{(V_1 - V_2)^2}{2}$ B. $\dfrac{(V_1 - V_2)^2}{4g}$

C. $\dfrac{V_2^2}{2g}\left(\dfrac{A_1}{A_2} - 1\right)^2$ D. $\dfrac{V_2^2}{2g}\left(\dfrac{A_2}{A_1} - 1\right)^2$

Ans. D

Sol.

Head loss due to sudden expansion,

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

we know $A_1V_1 = A_2V_2$

$$\frac{V_1}{V_2} = \frac{A_2}{A_1}$$

$$h_L = \frac{V_2^2}{2g}\left(\frac{A_2}{A_1} - 1\right)^2$$

23. Maximum value of C_{Pmax} (Power coefficient) and it occurs at a (interference factor) of respectively _____.

    A. $\frac{8}{9}, \frac{1}{3}$ B. $\frac{8}{9}, \frac{2}{3}$

    C. $\frac{16}{27}, \frac{2}{3}$ D. $\frac{16}{27}, \frac{1}{3}$

Ans. D

Sol. Power coefficient is given by:

    $C_P = 4a(1 - a)^2$

    It is maximum at $a = \frac{1}{3}$

    Thus: $C_{Pmax} = \frac{16}{27} = 0.593$.

24. It is desired to increase the heat dissipation rate from the surface of an electronic device of spherical shape of 5 mm radius exposed to convection, h = 10 W/m²K by encasing it in a spherical sheath of conductivity k = 0.04 W/m-K. For maximum heat flow, the thickness of the sheath should be _____.

    A. 8 mm   B. 2 mm

    C. 4 mm   D. 3 mm

Ans. D

Sol. Given:

    Electronic device of spherical shape: r = 5 mm radius

    Heat transfer coefficient: h = 10 W/m²K

    Thermal conductivity: K = 0.04 W/m-K

    For sphere critical radius of insulation:

    $$r_{cr} = \frac{2k}{h} = \frac{2 \times 0.04}{10} = 0.008 = 8mm$$

    Radius of electronic device: r = 5 mm

    Thickness: t = 8 − 5 = 3 mm

25. Which of the following mentioned boiler's is a once through boiler _____.

A. La-Mont Boiler B. Benson Boiler

C. Loeffler Boiler D. Schmidt–Hartman Boiler

Ans. B

Sol.

• One through boiler's is a boiler in which entire separation of feed water heating, steam formation and superheating takes along a single tube without use of boiler drum. Except Benson boiler, all three-boiler mentioned has boiler drum. Benson is once through boiler.

• **Lamont Boiler**: Forced circulation water tube boiler.

• **Loeffler boiler**: Forced circulation water tube boiler.

• **Schmidt–Hartman Boiler**:

26. Match the following lists

List-1	List-2
P: Critical point	1. All the three phases - solid, liquid and vapour co-exists in equilibrium
Q: Sublimation	2. Phase change from solid to liquid
R: Triple point	3. Properties of saturated liquid and saturated vapour are identical
S: Melting	4. Solid directly transformed to gaseous phase

A. P–2, Q–1, R–4, S–3 B. P–3, Q–4, R–1, S–2

C. P–2, Q–4, R–1, S–3 D. P–3, Q–1, R–4, S–2

Ans. B

Sol.

o **Critical point:** Properties of saturated liquid and saturated vapour are identical.

o **Sublimation**: heating process, where solid gets directly transformed to a gaseous phase.

o **Triple point:** All the three phases - solid, liquid and vapour co-exists in equilibrium.

o **Melting point**: phase change from solid to liquid.

27. If the entropy of the saturated liquid and saturated vapor at a particular saturation temperature (300K) are 2 kJ/kg.K and 7 kJ/kg.K. Determine the enthalpy of vaporization?

A. 1500 kJ/kg B. 700 kJ/kg

C. 300 kJ/kg D. 3000 kJ/kg

Ans. A

Sol. Given,

saturated liquid = 2 kJ/kgK,

saturated vapor = 7 kJ/kgK,

saturation temperature = 300K,

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

$$h_{fg} = s_{fg} \times T$$

$h_{fg} = 5 \times 300 = 1500\, kJ/kg$

28. The concentrator in which sunrays are tracked by two axis tracking mechanism to bring them to point of focus is _____.

A. Control receiver system B. Heliostat type concentrator

C. Paraboloid dish concentrator D. None of the above

Ans. C

Sol.

• "Paraboloid Dish Concentrator" is a concentrator in which direction of sunrays are tracked by two axis tracking mechanism to bearing them to a point of focus.

• Due to limitation of size of concentrator, this system can be used for domestic power generation.

29. A stream function is given by ψ=3x −4y . The resultant velocity at any point is _____.

A. 7 units   B. 5 units

C. 4 units   D. 3.5 units

Ans. B

Sol. Since:

$$u = -\frac{\partial \psi}{\partial y} = 4$$

$$v = \frac{\partial \psi}{\partial x} = 3$$

Resultant velocity is given by:

$$V = \sqrt{(x^2 + y^2)}$$

V= 5 units

30. In the world maximum carbon is found in

A. Oceans   B. Forests

C. Mines   D. Atmosphere

Ans. A

Sol. ⇒ In the world maximum carbon is found in Oceans.

⇒ The ocean, with around 38,000 gigatons (Gt) of carbon, contains 16 times as much carbon as the terrestrial biosphere.

⇒ Among the total quantity of global carbon 71% is found in oceans in dissolved form whereas only 1% is found in atmosphere.

31. The requirement of second law of thermodynamics for any process is that the entropy change of the system be _____.

A. Positive or zero   B. Zero

C. Positive, Zero or Negative   D. Negative

Ans. C

Sol.

o   The requirement for a process to be feasible according to second law of thermodynamics is that the entropy change of the universe must be greater than or equal to zero.

o   Entropy change of universe is the sum of entropy change of the system and surrounding. $dS_{univ} = dS_{sys} + dS_{surr} \geq 0$

o   But, there is no such condition for the entropy change of the system thus it may be positive, negative or zero depending on the conditions.

32. The outer surface of long cylinder is maintained at constant temperature. The cylinder does not have any heat source. The temperature in the cylinder will.
    A. increases linearly with radius
    B. decrease linearly with radius
    C. be independent of radius
    D. vary logarithmically with radius

Ans. D

Sol. Heat transfer in cylinder is given by:

$$Q = \frac{2\pi KL \times \Delta T}{\ln\left(\frac{r_2}{r_1}\right)}$$

Thus, heat transfer through the cylinder vary logarithmically.

33. In case of a hydraulic ram, which among the following caters the function of behaving it as pumping device _____?
    A. Centrifugal Effect
    B. Reciprocating effect
    C. Impulse effect
    D. Hydraulic cylinder

Ans. C

Sol.

o   A hydraulic ram pump is a water pump powered by water with a height difference. **Example:** In areas where natural flows exist with a height difference of the water over a small distance, hydraulic ram pumps can be used to transport water to higher grounds without using electricity or fuel.

o   The hydraulic ram uses the water hammer effect (Impulse) to develop pressure that allows a portion of the input water that powers the pump to be lifted to a point higher than where the water originally started.

34. Rankine cycle efficiency is _____ than/as Carnot cycle efficiency if both work under the same operating temperatures.
    A. more
    B. less
    C. Same
    D. Can be less or more

Ans. B

Sol. Though work output is more in case Rankine cycle, but its efficiency is less in comparison to Carnot vapour cycle because the mean temperature of heat addition is more for Carnot cycle.

35. In a certain ideal refrigeration cycle, the COP of the refrigerator is 3. The cycle under ideal conditions running as heat engine will have efficiency equals to
    A. 0.20
    B. 0.25
    C. 0.30
    D. 0.35

Ans. B

Sol.

$$(COP)_{HP} = 1 + (COP)_R = 1 + 3 = 4$$

$$(\eta)_{\text{heat engine}} = \frac{1}{(COP)_{HP}} = \left(\frac{1}{4}\right) = 0.25$$

36. A long fin of 5 cm diameter, made of aluminum (k = 237 W/m°C) is attached to a surface maintained at 100°C. Air flows over the surface at temperature 20°C with heat transfer coefficient of 10 W/m²C. If the fin can be assumed as infinitely long, its effectiveness is close to

A. 43   B. 36

C. 29   D. 14

Ans. A

Sol. Given,

diameter of the fin,d = 5 cm

Conductivity of fin material,k = 237 W/m°C

Base Temperature, T_0 = 100°C

Air temperature, T_∞ = 20°C

Heat transfer coefficient, h = 10W/m²C

For infinitely long fin,

$$\varepsilon = \frac{\sqrt{hpkA_c}(T_0 - T_\infty)}{hA_c(T_0 - T_\infty)} = \sqrt{\frac{pk}{hA_c}}$$

$$\varepsilon = \sqrt{\frac{\pi \times d \times k}{h\frac{\pi}{4} \times d^2}} = \sqrt{\frac{4k}{hd}} = \sqrt{\frac{4 \times 237}{10 \times 0.05}} = 43.54$$

37. In the psychrometric chart the process (1-2) is given [cooling dehumidification]. Find the percentage change in moisture (initial-final)

A. 40%   B. 60%

C. 50%   D. 45%

Ans. C

Sol. Since mass of dry air is const. So

$$\% \text{ charge in moisture} = \left(\frac{m_{V_1} - m_{V_2}}{m_{V_1}}\right)$$

$$= \left\{ \frac{m_a\omega_1 - m_a\omega_2}{m_a\omega_L} \right\} = \left(\frac{\omega_1 - \omega_2}{\omega_L} \right) \times 100$$

$$= \left(\frac{20 - 10}{20} \right) \times 100 = 50\%$$

(50% decrease in moisture contain)

38. Match the differentials in list 1 with the corresponding differentials in list 2

List-1

A). $\left(\frac{\partial P}{\partial T} \right)_v$

B). $\left(\frac{\partial T}{\partial v} \right)_s$

C). $\left(\frac{\partial T}{\partial p} \right)_s$

List-2

1). $-\left(\frac{\partial p}{\partial s} \right)_v$

2). $\left(\frac{\partial v}{\partial s} \right)_p$

3). $\left(\frac{\partial s}{\partial v} \right)_T$

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

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

Ans. A

Sol. By Maxwell equations:

$$\left(\frac{\partial P}{\partial T} \right)_v = \left(\frac{\partial s}{\partial v} \right)_T$$

$$\left(\frac{\partial T}{\partial v} \right)_s = -\left(\frac{\partial p}{\partial s} \right)_v$$

$$\left(\frac{\partial T}{\partial p} \right)_s = \left(\frac{\partial v}{\partial s} \right)_p$$

39. Joule-Thomson coefficient is the ratio of _____.

A. pressure change to temperature change occurring when a gas undergoes the process of adiabatic throttling

B. temperature change to pressure change occurring when a gas undergoes the process of adiabatic throttling

C. temperature change to pressure change occurring when a gas undergoes the process of adiabatic compression

D. pressure change to temperature change occurring when a gas undergoes the process of adiabatic compression

Ans. B

Sol.

o Joule-Thomson coefficient is given by $\mu_J = \left(\frac{dT}{dP}\right)_h$.

o Thus it is ratio of temperature change to pressure change occurring when a gas undergoes the process of adiabatic throttling.
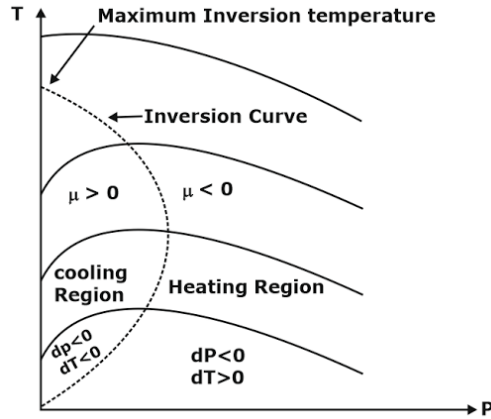
40. For maximum power generation the air fuel ratio for a petrol engine is

    A. 16:1   B. 12:1

    C. 15:1   D. 20:1

Ans. B

Sol. power characteristics curve of fuel
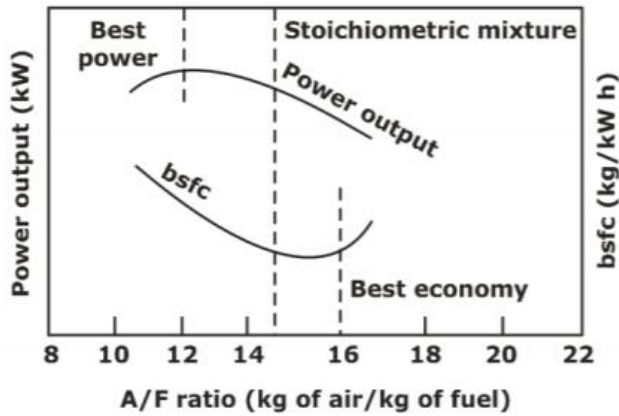
From the above figure, we can see that for maximum power output, Air to fuel ratio is to be 12:1

41. Sensible heat factor is given by _____. (Where S.H. - Sensible Heat, L.H. - Latent Heat).

    A. $\dfrac{S.H.}{S.H.+L.H.}$ B. $\dfrac{S.H.+L.H}{S.H.}$

    C. $\dfrac{S.H.}{L.H.-S.H.}$ D. $\dfrac{L.H-S.H.}{S.H.}$

Ans. A

Sol.

Sensible heat factor = $\dfrac{Sensible\,Heat}{Total\,Heat} = \dfrac{S.H.}{S.H.+L.H.}$

SHF will be 1 for Sensible heating.

42. Back work ratio for gas turbine can also be represented as _____.

A. $\dfrac{T_2}{T_1}$

B. $\dfrac{T_4}{T_3}$

C. $\dfrac{T_2 - T_1}{T_4 - T_1}$

D. $\dfrac{T_1}{T_4}$

Ans. D

Sol.

Back work ratio = $\gamma_{bw} = \dfrac{W_C}{W_T} = \dfrac{C_P(T_2 - T_1)}{C_P(T_3 - T_4)}$

$\gamma_{bw} = \dfrac{T_1\left(\dfrac{T_1}{T_2} - 1\right)}{T_4\left(\dfrac{T_3}{T_4} - 1\right)} \Rightarrow \boxed{\gamma_{BW} = \dfrac{T_1}{T_4}}$

$\boxed{\dfrac{T_2}{T_1} = \dfrac{T_3}{T_4}}$

43. Find the availability when 100kW of heat is delivered from a heat source at 500K to the ambient temperature is 300K.

A. 20 kW

B. 30 kW

C. 40 kW

D. 50 kW

Ans. C

Sol. availability is the maximum amount of the work that can be extracted form a given amount of heat

$\eta = 1 - \dfrac{T_L}{T_H} = \dfrac{Available\,energy}{heat\,supplied}$

$1 - \dfrac{300}{500} = \dfrac{Available\,energy}{100}$

Availability= 40kW

44. Most commonly used lubrication system in automobiles is the_____.

A. splash system

B. pressure system

C. petrol system

D. gravity system

Ans. B

Sol.

• Most commonly used lubrication system in automobiles is the pressure system.

• Splash system is not sufficient in case of bearing loads are high. In that case splash and pressure feed system may be used.

45. Single-stage piston compressors are used to compress air up to pressure of approximately _____ bar.

   A. 5   B. 100

   C. 150   D. 50

Ans. A

Sol. Pressure range of reciprocating compressor:

No. of stage	Maximum discharge pressure
Single stage	Up to 5.6 bar
Double stage	5.6-.5 bar
Triple stage	180 bar

46. A simple ideal Rankine cycle is having fixed boiler and condenser pressure. If the cycle is modified with reheating,

   A. the turbine work output will decrease

   B. the amount of heat rejected will decrease

   C. the pump work input will increase

   D. the moisture content at turbine exit will decrease

Ans. D

Sol. In the simple ideal Rankine cycle modified with reheating, reheating is a practical solution to the excessive moisture content problems in turbines.

47. At the Solar noon, the hour angle is _____.

   A. 90°   B. – 90°

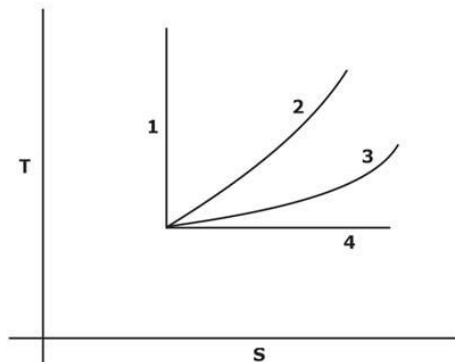   C. Zero   D. 180°

Ans. C

Sol. Hour angle (ω) is given by:

   ω = [12:00 – Solar time] (in hours) × 15 degrees

   At solar noon: Solar time = 12:00

   ω = [12:00 – 12:00] × 15 degrees

   $\boxed{\omega = 0°}$

48. T-S plot for various processes are given

   Match List I (Process) with List II (T-S Curve) and select the correct answer using the code given below the Lists:

List 1		List 2	
A.	Isochoric	1.	1
B.	Isothermal	2.	2
C.	Isobaric	3.	3
D.	Adiabatic	4.	4

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

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

Ans. D

Sol. Isothermal is T=constant, Hence curve 4 implies it.

Adiabatic: reversible adiabatic processes are isentropic (ie. S=constant), Hence curve 1 fits.

For isobaric process $T\,dS = C_P\,dT = \left(\dfrac{dT}{dS}\right)_{isobaric} = \dfrac{T}{C_p}$

For isochoric process $TdS = C_v dT = \left(\dfrac{dT}{dS}\right)_{isochoric} = \dfrac{T}{C_v}$

We know that $C_p > C_v$

And Slope of isochoric curve > Slope of isobaric curve

Hence curve 2 is isochoric and curve 3 is isobaric

49. For a closed system, if heat transferred is equal to change in enthalpy, the process will be

A. Constant pressure process   B. Constant volume process

C. Isothermal process   D. Adiabatic process

Ans. A

Sol. We know that, δQ = dU + δW

If δW = 0, then δQ = dU

Also we know that, δW = pdV

So, δQ = dU + pdV

At constant pressure, δQ = dU + d(pV) = d (U + pV) = dH

50. Find the heat transfer (in kJ) during a certain process having variable specific heat C = (0.5 + 0.5 T) kJ/ºC. If its temperature changes from 10ºC to 100ºC

A. 2520   B. 2520.12

C. 2519.98   D. 2521

Ans. A

Sol. Given,

Variable heat capacity,

C = (0.5 + 0.5T) kJ/ºC

Heat transfer when temperature changes from 10ºC to 100ºC

$Q = \int mCdT$

$= \int_{10}^{100} 1 \times (0.5 + 0.5T)\,dt$

$$= 0.5 \left[T + \frac{T^2}{2} \right]_{10}^{100}$$

$$= 0.5 \left[(100 - 10) + 0.5 \times (100^2 - 10^2) \right]$$

Q = 2520 kJ

51. Atmospheric air at 100 kPa & 30°C has relative humidity of 60%. If saturation pressure is 5.25. Then what will be dry air pressure?

A. 96.85 kPa   B. 3.15 kPa

C. 31.5 kPa   D. Can't be determined

Ans. A

Sol. Given φ = 60%,

P_t = 100 kPa = P_a + P_v

P_{VS} = 5.25 kPa

$$\phi = \frac{P_v}{P_{vs}} \Rightarrow 0.6 = \frac{P_v}{5.25} \Rightarrow P_v = 3.15 \ kPa$$

P_t = P_a + P_v = 100

$\Rightarrow P_a$ + 3.15 = 100

P_a = 96.85 kPa

52. Lagrangian approach of fluid flow involves_____.

A. Tracking fluid particles through a fixed control volume

B. Tracking fluid particles of fixed identity

C. Tracking fluid particles for a period of time in a fixed coordinate system

D. None of these

Ans. B

Sol. * In the Lagrangian approach, the individual fluid particles of fixed identity are traced.

* In Eulerian approach, there is the consideration of flow domain of fixed control volume/coordinate system.

53. A refrigeration plant uses a condenser with heat rejection ratio of 1.2. If the capacity of the plant is 210 kJ/min, then the value of the *COP* of the refrigeration plant is

A. 3   B. 5

C. 7   D. 9

Ans. B

Sol.

$$HRR = \frac{Qc}{RE} = \frac{RE + W}{RE} = 1 + \frac{W}{RE}$$

$$HRR = 1 + \frac{1}{COP}$$

Then, $1.2 = 1 + \dfrac{1}{COP}$

$\therefore COP = 5$

54. A pump handling a liquid raises its pressure from 1 bar to 30 bar. Take the density of the liquid as 990 kg/m^3. The isentropic specific work done by the pump (in kJ/kg) is _____.

A. 0.10   B. 0.30

C. 2.50   D. 2.93

Ans. D

Sol. The specific work done by the pump is given as:

$$w = \int_{p_1}^{p_2} v\, dp = \int_{10^5}^{30 \times 10^5} \frac{1}{\rho} dp$$

$$w = \frac{1}{990}[p]_{10^5}^{30 \times 10^5} = 2.929 \times 10^3 \; J$$

55. A gas mixture consists of 4 kg of O_2, 6 kg of N_2 and 15 kg of CH_4. The mass fraction and mole fraction of N_2 are_____.

A. 0.24 and 0.287   B. 0.24 and 0.167

C. 0.24 and 0.265   D. 0.16 and 0.287

Ans. B

Sol. Given: $m_{CH4} = 15$ kg

$m_{O2} = 4$ kg

$m_{N2} = 6$ kg

For N_2:

Mass fraction $(\alpha) = \dfrac{m_{N_2}}{m_{N_2} + m_{CH_4} + m_{O_2}}$

$\alpha = \dfrac{6}{6 + 4 + 15} = 0.24$

Mole fraction $(m) = \dfrac{n_{N_2}}{n_{N_2} + n_{CH_4} + n_{O_2}}$

$$= \dfrac{\dfrac{6}{28}}{\dfrac{4}{32} + \dfrac{15}{16} + \dfrac{6}{28}}$$

Mole fraction (m) = 0.167

56. An oil cooler in a high performance engine has an outside area 0.12 m^2 and surface temperature of 65°C . At any intermediate time air moves over the surface of the cooler at a temperature of 30°C and given heat transfer coefficient equal to $45.4 \dfrac{W}{m^2 K}$ Find out the heat transfer rate?

A. 238.43 W   B. 190.68 W

C. 543.67 W   D. 675.98 W

Ans. B

Sol. Given,

Outside area= 0.12 m^2,

Surface temperature = 65°C ,

Surrounding temperature =30°C,

heat transfer coefficient = $45.4 \frac{W}{m^2 K}$

Q = h A(T$_S$ − T$_\infty$)

= 45.4 × 0.12 × (65 − 30)

= 190.68 W.

57. What is the molecular weight of the gas whose specific heat are as follows.

$$C_p = 1.996 \frac{kJ}{kgK} \quad C_v = \frac{1.507 kJ}{KgK}$$

A. 17kg/k-mol   B. 18kg/k-mol

C. 19kg/k-mol   D. 20kg/k-mol

Ans. A

Sol. Using Meyer's equation,

$$C_p - C_v = \frac{R}{M}$$

R = universal gas constant = 8.314 kJ/kg-molK

Substituting the values,

1.996 − 1.507 = 8.314/M

M = 17.00 kg/k-mol [Ans]

58. For a fluid having Prandtl number equal to unity, how are the hydrodynamic boundary layer thickness (δ) and the thermal boundary layer thickness (δ$_t$) related _____?

A. δ = δ$_t$ B. δ >δ$_t$

C. δ < δ$_t$ D. δ$_t$ = δ$^{1/3}$

Ans. A

Sol. Thermal boundary layer thickness (δ$_t$) is given by:

$$\delta_t = \frac{\delta}{Pr^{1/3}}$$

(i) when Pr =1; δ$_t$ = δ

(ii) when Pr >1; δ$_t$ < δ

(iii) when Pr<1; δ$_t$ > δ

59. Laminar flow in pipe, the maximum velocity is found to be 60 cm/sec. The average velocity of the flow (in cm/sec) is_____.

A. 40   B. 60

C. 30   D. 20

Ans. C

Sol. Given,

Maximum velocity =60 cm/sec,

Average velocity=?

In case of pipe,

$U_{max.} = 2 U_{avg.}$

$60 = 2 U_{avg.}$

$U_{avg.} = 30$ cm/s

60. The time period of oscillation of a floating body is T. If the time period changes to 2T, the metacentric height_____.

A. Increases by a factor of 2   B. Increases by a factor of 4

C. Decreases by a factor of 2   D. Decreases by a factor of 4

Ans. D

Sol.

- The time period of the oscillation of a floating body is inversely proportional to the square root of the metacentric height.

$$T = 2\pi \sqrt{\frac{k^2}{g\,(GM)}}$$

where GM is metacentric height and T is time period of oscilation,

k = Radius of gyration.

- The time period of the oscillation of a floating body is inversely proportional to the square root of the metacentric height.

$$T \alpha \sqrt{\frac{1}{GM}}$$

$$\frac{T_2^{\,2}}{T_1^{\,2}} = \frac{GM_1}{GM_2}$$

Given,

$T_2 = 2T_1$

$$4 = \frac{GM_1}{GM_2}$$

$$GM_2 = \frac{GM_1}{4}$$

- Therefore, when T changes to 2T, Metacentric height will reduce by a factor of 4

61. If m is the ratio of maximum and minimum temperature of Brayton cycle, then the efficiency corresponding to the maximum work done is given by the relation _____.

A. $\eta = 1 + \dfrac{1}{\sqrt{m}}$

B. $\eta = 1 - \dfrac{1}{\sqrt{m}}$

C. $\eta = 1 - \sqrt{m}$

D. $\eta = 1 + \sqrt{m}$

Ans. B

Sol. Given:

$$m = \frac{T_{max}}{T_{min}}$$

For maximum work done, cycle efficiency is:

$$\eta = 1 - \sqrt{\frac{T_{min}}{T_{max}}} = 1 - \frac{1}{\sqrt{m}}$$

62. The most appropriate example of _____ boiler is Cornish boiler.

A. water tube

B. flue gas

C. multi-tubular

D. fire tube

Ans. D

Sol. Cornish boiler is an example of fire tube boiler and includes Cochran, Lancashire, and Locomotive and scotch marine boilers.

63. Detonation in the SI engine can be reduced by _____.

A. Increasing the compression ratio

B. Increasing the engine speed

C. Increasing the cooling water temperature

D. Supercharging

Ans. B

Sol. Detonation/Knocking in the SI engine can be reduced by:

o Decreasing the compression ratio.

o Increasing the engine speed.

o Increasing the cooling rate.

o Retarding spark.

64. Specific humidity of moist air is function of _____.

A. Atmospheric pressure only

B. Atmospheric pressure & vapour pressure

C. Vapour pressure & dry air pressure

D. Vapour pressure only

Ans. D

Sol.

Specific humidity $= \omega = 0.622 \dfrac{P_v}{P_t - P_v}$ 	$\begin{bmatrix} P_t = \text{total pressure} = \text{constant} \\ P_v = \text{vapour pressure} \end{bmatrix}$

Since the total atmospheric pressure remains constant at particular locality.

Thus, ω = f(P$_v$) only.

65. A pipe of the rectangular cross-section has length and breadth 4 m and 1 m respectively. The equivalent diameter is _____.

A. 3.2 m   B. 4 m

C. 1.6 m   D. 2.4 m

Ans. C

Sol. Equivalent diameter of pipe is given by:

$$D_{eq} = \frac{4A_c}{P}$$

$$D_{eq} = \frac{4 \times 4 \times 1}{2 \times (4+1)} = 1.6 \; m$$

66. A steam plant has the boiler efficiency of 82%, turbine efficiency (mechanical) of 84%, generator efficiency of 85%. If 6% of the generated power is used to run the auxiliaries, the overall plant efficiency is _____.

A. 55%   B. 36%

C. 45%   D. 30%

Ans. A

Sol. Since overall efficiency is given by:

$$\eta_{overall} = \eta_{Boiler} \times \eta_{mech} \times \eta_{gen} \times \eta_{aux}$$

$$\eta_{overall} = 0.82 \times 0.84 \times 0.85 \times 0.94 = 0.5503$$

$\eta_{overall}$ = 55.03%

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

A. $\oint \frac{dQ}{T} = 0$

B. $\oint \frac{dQ}{T} > 0$

C. $\oint \frac{dQ}{T} < 0$

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: $\oint \frac{dQ}{T} > 0$

68. A carnot engine operates between 27°C and 227°C. If the engine produces 250 kJ of work, the heat added is_____.

A. 500 kJ   B. 600 kJ

C. 625 kJ   D. 650 kJ

Ans. C

Sol.   For carnot engine,

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

$$\eta = 1 - \frac{300}{500}$$

$$= 0.4$$

Now,

$$\eta = \frac{Work\ done}{Heat\ addition}$$

$$\Rightarrow Heat\ addition = \frac{250 \times 5}{2}\ kJ = 625\ kJ$$

So, the correct option is (c).

69.   For a living human body to feel comfortable, the heat produced by the metabolic activity of body should be equal to

A. Heat dissipated to the surroundings

B. Heat stored in the human body

C. Sum of (A) and (B)

D. Difference of (A) and (B)

Ans. C

Sol.   For Heat Balance: Heat In = Heat out.

In case of human body to feel comfortable,

Heat produced by the metabolic activity = Heat dissipated to the surroundings + Heat stored in the human body

70.   What is the purpose of cut- off governing of steam engines?

A. Controlling the engine output by varying volume of intake steam

B. Controlling the engine output by varying pressure of intake steam

C. Controlling the engine output by varying temperature of intake steam

D. All of the above

Ans. A

Sol.   Cut off governing of compound steam engine is a method to control the engine output by varying volume of intake steam in H.P. cylinder. It is done by varying cut off point under the control of centrifugal governor.

71.   Laminar boundary layer thickness measured at a distance 'x' from the leading edge of a flat plate varies as

A. $\dfrac{1}{\sqrt{x}}$ B. $\sqrt{x}$

C. $x^{\frac{3}{2}}$ D. $\dfrac{1}{x^{\frac{3}{2}}}$

Ans. B

Sol.   We know that,

Laminar boundary layer thickness, $\delta = \dfrac{5x}{\sqrt{R_{ex}}}$ where, $R_{ex} = \dfrac{\rho\,v\,x}{\mu}$

So, $\delta = \dfrac{5x}{\sqrt{\dfrac{\rho\,v\,x}{\mu}}} = \dfrac{5x^{\frac{1}{2}}}{\sqrt{\dfrac{\rho\,v}{\mu}}} \propto x^{\frac{1}{2}}$

72.   In an air standard cycle, indicated power is 80 KW and mechanical efficiency is 85%.
      Then the frictional power will be

      A. 68 kW   B. 12 kW

      C. 14 kW   D. 15 kW

Ans. B

Sol.   Given $\eta_M = 85\%$, IP = 80 KW

      $\eta_M = \dfrac{BP}{IP} \Rightarrow 0.85 = \dfrac{BP}{80} \Rightarrow BP = 68\ KW$

      IP = BP + FP ⇒ FP = IP − BP

      = 80 − 68

      FP = 12 kW

73.   If 3000 kJ/kg heat is added to the system & work done on the system is 6000kJ/kg, then
      change in internal energy is given by

      A. 9000 kJ/kg   B. 3000 kJ/kg

      C. -3000 kJ/kg   D. None of these

Ans. A

Sol.   We know that heat added to the system is taken as positive and work done on the system
      is taken as negative,

      Here Q= 3000kJ/kg, W= -6000 kJ/kg

      According to first law of thermodynamics,

      Q = ΔU + W

      3000 = ΔU − 6000

      ΔU = 9000kJ/kg

74.   Which of the following assumption are used to convert generalized unsteady flow energy
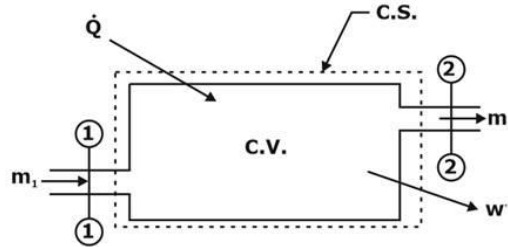   equation to given form?

      $\dfrac{dU}{dt} = \left[\dot{m}_i h_i + \dot{Q}\right] - \left[\dot{m}_e h_e + \dot{w}\right]$

      1) Neglecting kinetic energy change.

2) Neglecting potential energy change.

3) Neglecting the variation of enthalpy at inlet and outlet with respect to time.

A. 1 and 3 only   B. 1 and 2 only

C. 2 and 3 only   D. 1, 2 and 3

Ans. D

Sol.   * Unsteady flow means the properties varies with respect to time.

Mass balance: The rate at which the mass of fluid within the control volume is accumulated is equal to the net rate of mass flow across the control volume.

* Apply conservation of mass:

$$\left(\frac{dm}{dt}\right)_{cv} = (\dot{m}_i - \dot{m}_e)$$

* From energy conservation

$$\left(\frac{dE}{dt}\right)_{c.v.} = \frac{d}{dt}(m_i h_i + K.E. + P.E + Q) - \frac{d}{dt}[m_e h_e + K.E. + P.E. + W]$$

* 1st assumption neglection kinetic energy $\Delta KE = 0$

* 2st assumption neglection potential energy $\Delta PE = 0$

$$\left(\frac{dU}{dt}\right)_{cv} = \frac{d}{dt}(m_i h_i + Q) - \frac{d}{dt}(m_e h_e + W)$$

* 3rd assumption neglecting the variation of enthalpy at inlet and outlet with respect to time.

$$\left(\frac{dU}{dt}\right)_{cv} = \frac{d}{dt}(m_i h_i + Q) - \frac{d}{dt}(m_e h_e + W)$$

$$= \frac{d}{dt}(m_i h_i) + \frac{dQ}{dt} - \frac{d}{dt}(m_e h_e) - \frac{dW}{dt}$$

$$\frac{dU}{dt} = h_i \frac{dm_i}{dt} + \dot{Q} - h_e \frac{dm_e}{dt} - \dot{W}$$

$$\frac{dU}{dt} = \dot{m}_i h_i + \dot{Q} - h_e \dot{m}_e - \dot{W}$$

$$\frac{dU}{dt} = [\dot{m}_i h_i + \dot{Q}] - [\dot{m}_e h_e + \dot{W}]$$

75.   Which of the following is the correct relation of fill form factor _____.

A. $FF = \dfrac{V_m I_m}{V_{oc} I_{sc}}$ B. $FF = \dfrac{V_m}{I_m} \times \dfrac{I_{sc}}{V_{oc}}$

C. $FF = \dfrac{I_m}{I_{sc}} \times \dfrac{V_{oc}}{V_m}$ D. $FF = \dfrac{I_{sc} V_{oc}}{V_m I_m}$

Ans. A

Sol. **"Fill form factor":**

Fill form factor (FF), which indicates the quality of cell, is defined as the peak power to the product of open circuit voltage and short circuit current i.e.

$$FF = \frac{V_m I_m}{V_{oc} I_{sc}}$$

V_{OC} = open circuit Voltage

I_{SC} = Short circuit current

76. The height of Hg column is 5 cm if Hg in a barometer is replaced by water, the height if water column will be (in cm)_____?

    A. 68   B. 65

    C. 70   D. 62

Ans. A

Sol. Given,

height of Hg column = 5 cm

S=Specific gravity; H=Column height

$S_1 H_1 = S_2 H_2$

13.6 x 5 = 1 x H_2

H_2 = 68 cm;

77. The local heat transfer coefficient (in W/m^{2}K) at a point is given as $h_x = 15.6x$. The average heat transfer coefficient for a length of 8 m is :

    A. 62.4   B. 78

    C. 19.5   D. 10

Ans. A

Sol. The average heat transfer coefficient is given by :

$$h_{avg} = \frac{1}{L}\int_0^L h_x dx$$

$$= \frac{1}{8}\int_0^8 15.6x\, dx = \frac{15.6}{8} \times \frac{64}{2}$$

$$h_{avg} = 62.4\,W/m^2K$$

78. After expansion from a gas turbine, the hot exhaust gases are used to heat the compressed from a compressor with the help of a counter flow compact heat exchanger of 0.6 effectiveness. The number of transfer units of the heat exchanger is _____.

    A. 1.5   B. 2.5

    C. 3.5   D. 4.5

Ans. A

Sol. For a gas turbine:

Heat capacity ratio (C) = 1

Effectiveness: $\varepsilon = \dfrac{NTU}{1+NTU}$

$0.6 = \dfrac{NTU}{1+NTU}$

$0.4NTU = 0.6$

NTU = 1.5

79. For a non-black surface, absorptivity is 0.37 & reflectivity 0.29. Then the emissivity of the surface when the body is in thermal equilibrium with surrounding is

A. 0.34   B. 0.37

C. 0   D. 0.71

Ans. B

Sol. As per the kirchoff's law.

When the body is in thermal equilibrium with the surrounding then its absorptivity equal to emissivity

ɑ = ε

Thus ε = ɑ = 0.37

80. Which of the following is not a type of thermal storage device _____?

A. Sensible heat storage device

B. Gasifier

C. Latent storage device

D. Theron-chemical storage device

Ans. B

Sol. Type of thermal energy storage devices:

1. Sensible heat storage device

2. Latent heat storage device

3. Theron-chemical storage device

Gasifier: The gasifier unit is essentially a chemical reactor where several Theron-chemical processes such as pyrolysis, combustion and reduction take place.

81. Which of the following is correct about refrigerant in a vapour compression cycle

A. Refrigerant should have a large latent heat of vaporization at condenser pressure

B. Refrigerant should have a large latent heat of vaporization at evaporator pressure

C. Refrigerant should have condenser pressure close to critical pressure

D. Refrigerant should have low critical pressure

Ans. B

Sol.

• Both condenser and evaporator pressure should be above atmospheric pressure and as near to atmospheric pressure as possible.

• A refrigerant should have a high latent heat of vaporization at the evaporator pressure.

• The high latent heat results in high refrigerating effect per kg of refrigerant circulated.

82. If air at 20 °C is heated to 25 °C using heater with a surface temperature of 30 °C then, the bypass factor is _____.

A. 2.0   B. 0.5

C. 1.0   D. None of the above

Ans. B

Sol. Bypass factor for the heating coil is given by:

$$BPF = \frac{T_s - T_o}{T_s - T_i}$$

Where: T_s = coil surface temperature

T_i = inlet air temperature

T_o = outgoing air temperature

BPF $= \dfrac{30 - 25}{30 - 20} = \dfrac{5}{10} = 0.5$

83. In a throttling process for ideal gas the

A. Volume remains constant

B. Pressure Remains Constant

C. Temperature remains constant

D. All three remains constant

Ans. C

Sol.

• The process in which a high pressure fluid is converted to low pressure by using a throttle valve is Throttling.

• In throttling process, enthalpy remains constant, as enthalpy is a function of temperature so temperature will not change during throttling process.

84. A gas turbine working on brayton cycle has minimum and maximum temperature limits of 300K and 1500K. What will be efficiency of cycle for max work output_____.

A. 48.73%   B. 55.27%

C. 37.63%   D. 63.42%

Ans. B

Sol. Given:

T_{min} = 300 K and T_{max} = 1500 K

For max work output:

$$\eta_{opt} = 1 - \sqrt{\frac{T_{min}}{T_{max}}}$$

$$\eta_{opt} = 1 - \sqrt{\frac{300}{1500}} = 1 - \sqrt{\frac{1}{5}}$$

$$\eta_{opt} = 1 - \frac{1}{2.2} = 0.5527$$

η_{opt} = 55.27 %

85. Lawn sprinklers work on the principle of _____.
    A. Impulse principle   B. Work energy principle
    C. Moment of Momentum principle   D. None of the above

Ans. C

Sol.

o   A sprinkler employs concepts of energy and the sprinkler spouts water while rotation, it is using kinetic (movement) mechanical energy.

o   The moment of momentum equation can be applied to analyse rotating systems, such as turbines, sprinklers, and fans.

86. The ratio of the beam of the radiation flux falling on a tilted surface to that falling on horizontal surface is _____.
    A. Total flux on tilted surface   B. Irradiation
    C. Collector efficiency   D. Tilt factor

Ans. D

Sol. The ratio of the beam radiation flux falling on a tilted surface to that of falling on a horizontal surface is called "Tilt factor".

87. Arrange the various zones of Gasifier in descending order of their temperatures in that zone _____.
    A. Drying zone, Reduction zone, Oxidation zone, Pyrolysis zone
    B. Pyrolysis zone, Oxidation zone, Reduction zone, Drying zone
    C. Oxidation zone, Reduction zone, Pyrolysis zone, Drying zone
   D. Oxidation zone, Pyrolysis zone, Reduction zone, Drying zone

Ans. C

Sol.

Gasifier Zone	Temperature
Drying zone	100°C
Pyrolysis zone	300°C
Oxidation zone	900°C
Reduction zone	600°C

88. Which of the following statement are correct regarding Rankine cycle?
    A. Efficiency of Rankine cycle is greater than Carnot cycle.
    B. Pump work is more in Rankine cycle than Carnot cycle.
    C. Net-work output is more in Rankine cycle than Carnot cycle.
    D. Pressure rise in pump will be same for both cycles.

Ans. C

Sol.
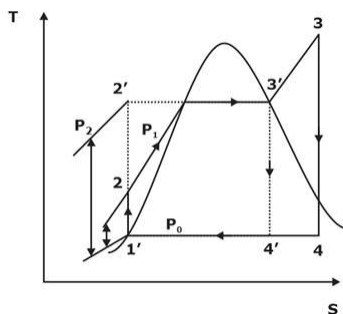
1 – 2 – 3 – 4 ⇒ Rankine cycle

1 – 2′ – 3′ – 4′⇒ Carnot cycle

Carnot cycle is an ideal cycle thus efficiency of Carnot is higher than Rankine cycle

Pressure rise in Rankine cycle is $(P_1 - P_2)$
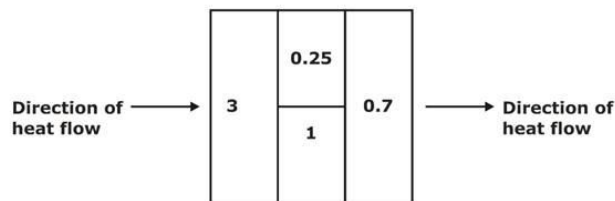
Pressure rise in Carnot cycle $(P_2 - P_{2'})$

Here

$(P_1 - P_{2'}) > (P_1 - P_2)$

When presence rise is more then, pump work will also be more.

W_{Net} is the area under the curve thus W_{Net} is more Rankine cycle.

89. A composite wall is made of four different materials of construction as shown in figure. The resistance (in kW) of each sections of the wall is indicated in the diagram.
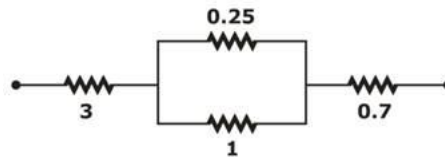

The overall resistance (K/W) of the composite wall in the direction of heat flow is

_____.

A. 3.9   B. 4.0

C. 4.2   D. 4.5

Ans. A

Sol. Overall network diagram is given by:

$$\Sigma R_{th} = 3 + \frac{0.25 \times 1}{0.25 + 1} + 0.7 = 3.7 + \frac{0.25}{1.25} = 3.9$$

90. What is the tip speed ratio of savonius wind turbine rotor ?

A. 1   B. 3

C. 5   D. 7

Ans. A

Sol. Tip speed ratio of the wind turbine is given by,

$$TSR = \frac{\text{speed of tip of the rotor blade}}{\text{speed of oncoming air}} = \frac{r\omega}{u_0}$$

Where,

r = Radius of the tip of the wind turbine

ω = Angular velocity of the turbine hub

u_0 = Speed of the oncoming air to turbine blades

tip speed ratio of savonius wind turbine rotor is 1.

91. The path traced by a fluid particle over a period of time is_____.

   A. Flow line
   B. Path line
   C. Stream line
   D. Streak line

Ans. B

Sol.

• Path line is the path traced by fluid particle over a given period of time.

• Stream line (also known as flow line) is one whose tangent at any point gives the velocity of flow at that point.

• Streak line is the locus of different particles passed through a particular point at a particular time.

92. 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.

93. In a VARS system, Heat is supplied to the Generator at 177°C, refrigerated space is maintained at –23°C. If the ambient temperature is 27°C then what will be the COP of the system.

   A. 0.6
   B. 1.66
   C. 0.185
   D. 0.55

Ans. B

Sol. Given

$T_G = 177°C = 450$ k, $T_E = -23°C = 250$ k

$T_0 = 27°C = 300$ k

$$COP = \frac{T_E(T_G - T_0)}{T_G(T_0 - T_E)} = \frac{250 \times (450 - 300)}{450 \times (300 - 250)}$$

$$= \frac{250 \times 150}{450 \times 50}$$

$$COP = \frac{5}{3} = 1.66$$

94. In a simple delaval turbine, the nozzle angle at the entrance is 60°. What is the blade speed ratio (u/V) for maximum diagram efficiency?

   A. 0.25
   B. 0.5
   C. 0.33
   D. 0.707

Ans. A

Sol. Given, nozzle angle = 60°

For maximum diagram efficiency,

$$\frac{u}{V} = \frac{\cos a}{2} = \frac{\cos 60°}{2} = \frac{1}{4}$$

$$\frac{u}{V} = 0.25$$

95. Solar energy stored in material such as wood, grain, sugar and municipal waste is called
    _____.

    A. Fossil fuel   B. Biomass

    C. natural gas   D. Geothermal energy

Ans. B

Sol.

> • Biomass is form of organic which is obtained from living organisms, such as plants and animals.
>
> • The most common biomass materials used for energy are plants, wood, and waste.

96. For what wavelength the black body's emissive power reaches at its maximum value when maintained at 100°C _____?

    A. 7.7 μm B. 28.98 μm

    C. 77 μm D. 2.898 μm

Ans. A

Sol. Using Wien's displacement law:

$$\lambda_{max}T = 2898 \ \mu m - K$$

T = 100 + 273 = 373 K

$$\lambda_{max} = \frac{2898}{373} = 7.769 \ \mu m$$

97. For a turbulent flow of a pipe, the head loss is approximate_____.
    (where V is mean velocity of flow)

    A. directly proportional to the velocity   B. inversely proportional to the velocity

    C. directly proportional to V^2 D. inversely proportional to V^2

Ans. C

Sol.

For a turbulent flow of a pipe,

$$h_f = \frac{fL\overline{V}^2}{2gD}$$

where

h_f = head loss of pipe

L = length of a pipe of diameter D,

$\overline{V}$ = mean velocity in the pipe

f = friction factor,

So,

$$h_f \ a \overline{V}^2$$

So, h_f for turbulent flow head loss is directly proportional to v^2.

98. Water flows through a circular tube with a velocity of 2 m/s. The diameter of the pipe is 14 cm. Take kinematic viscosity of water 10^{-6} m^2/s and density of water 1000 kg/m^3. what will be the Reynolds no?

A. 2.8×10^8 B. 2.8×10^5

C. 2800   D. 28000

Ans. B

Sol. Given,

Velocity = 2 m/s

Diameter =14 cm= 0.14m

Kinematic viscosity = 10^{-6} m^2/s

Density of water =1000 kg/m^3

Reynolds number is given by:

$$Re = \frac{\rho VD}{\mu} = \frac{VD}{v}$$

Thus,

$$Re = \frac{2 \times 0.14}{10^{-6}} = 2.8 \times 10^5$$

99. Atmospheric pressure is 101.325 kPa. Height of water column from the mean sea level which is equivalent to an absolute pressure of 140 kPa is _____.

A. 14.27 m   B. 3.94 m

C. 4.27 m   D. 13.94 m

Ans. B

Sol. Since relation between atmospheric pressure, gauge and absolute pressure is given by:

$$P_{atm} + P_{gauge} = P_{abs}$$

$$101.325 + \frac{\rho gh}{1000} = 140$$

$$\frac{1000 \times 9.81 \times h}{1000} = 38.675$$

$$h = 3.94 \ m$$

100. Which of the devices used for measuring rate of flow_____.

A) Orifice

B) Venturimeter

C) Mouthpieces

A. A & B   B. B & C

C. C & A   D. A, B & C

Ans. D

Sol. (i) Orifice is a small opening of any cross section on the side or at bottom of any tank used for measure rate of flow.

(ii) Venturimeter is used for measuring rate of flow.

(iii) Mouthpieces is a short length of pipe which is 2 to 3 time of diameter pipe used for measuring rate of flow.

101. World Soil Day is observed every year on_____.

   A. 4th December   B. 6th December

   C. 5th December   D. 7th December

Ans. C

Sol.

   • World Soil Day is observed every year on **December 5**.

   • The World Soil Day 2021 was observed with the theme **"Halt soil salinization, enhance soil production".**

   • The proposal for a World Soil Day was first recommended in the year 2002 by the International Union of Soil Sciences (IUSS).

   • In 2013, the United Nations General Assembly declared December 5, 2014, to be the first official World Soil Day.

102. Recently Haiderpur Wetland has been recognized as 47th Ramsar site in India, it is located in which of the following states of India?

   A. Uttar Pradesh   B. Madhya Pradesh

   C. Tamil Nadu   D. Maharashtra

Ans. A

Sol. • **Haiderpur Wetland has been recognized as 47th Ramsar site in India**.

   • It is located in Western Uttar Pradesh.

   • It is a man-made wetland, spreads over an area of 6,908 hectares in Bijnor, Uttar Pradesh.

   • It was formed in 1984.

   • It is the part of Hastinapur Wildlife Sanctuary.

   • As of December 2021, there are currently 2463 Ramsar sites around the world.

   • The Ramsar Convention is also known as the Convention on Wetlands.

   • It is named after the city of Ramsar in Iran, where the convention was signed in 1971.

103. Who won the 2021 Vijay Hazare Trophy?

   A. Tamil Nadu   B. Gujarat

   C. Madhya Pradesh   D. Himachal Pradesh

Ans. D

Sol. Himachal Pradesh defeated Tamil Nadu by 11 runs to win the first-ever Vijay Hazare Trophy. Hence, option D is correct.

   Explanation)

   • Shubham Arora's unbeaten 136 runs helped Himachal Pradesh defeat Tamil Nadu to win their first Vijay Hazare Trophy title recently in Jaipur.

   • Himachal Pradesh won the Vijay Hazare Trophy by defeating Tamil Nadu by 11 runs using the VJD method.

https://indianexpress.com/article/sports/cricket/himachal-pradesh-create-history-win-vijay-hazare-trophy-7691442/

104. Who among the following has been named as Time Magazine's Person of the Year 2021?

A. Narendra Modi   B. Joe Biden

C. Elon Musk   D. Pope Francis

Ans. C

Sol.   * **Tesla CEO Elon Musk** has been named **Time Magazine's "person of the year 2021**.

* Elon Musk is also the Founder and Chief Executive of space exploration company SpaceX.

* He also heads brain-chip start-up Neuralink and infrastructure firm The Boring Company.

* Mahatma Gandhi is the only Indian to be named TIME Person of the Year, having been given the honour in 1930.

105. Who among the following awarded the Ramanujan Prize 2021?

A. Neena Gupta   B. Sourav Chatterjee

C. Kavita Ramanan   D. Sanjeev Arora

E. None of the above

Ans. A

Sol.   * **Professor Neena Gupta** has been awarded the **2021 Ramanujan Prize**.

* She has been awarded for her outstanding work in affine algebraic geometry and commutative algebra.

* She is a mathematician at the Indian Statistical Institute in Kolkata.

* She is the fourth Indian to win the award. Ritabrata Munshi (2018), Amalendu Krishna (2015) and Sujatha Ramdorai (2006) from India have won the prize before.

* Ramanujan Prize was first awarded in **2005**.

* The Ramanujan Prize awarded annually by the International Centre for Theoretical Physics in Italy.

* It is given to researchers less than 45 years of age.

106. Who was the President of Congress when the Surat Split occurred?

A. Ras Bihari Ghosh   B. Dadabhai Naoroji

C. Annie Besant   D. Feroz Shah Mehta

Ans. A

Sol.   The Indian National Congress was founded in 1885. There was a rift on ideological basis between two factions of Congress. While one of the groups named Moderates were the conservatives following the path of prayers and petitions, the other or the extremists believed in more radical action. This led to a split in Congress in its Surat Session-1907. The session which was shifted from Nagpur to Surat by Pheroz Shah Mehta was presided over by Ras Bihari Ghosh, though not without confrontation.

107. Where did Tilak establish the Home Rule League?

    A. Belgaum   B. Mysore

    C. Patna   D. Lucknow

Ans. A

Sol. Tilak founded the Home Rule League on 28 April 1916 in Belgaum. It was chaired by Joseph Baptista and Secretary NC Kelkar. Its committee members were GS Khaparde, BS Moonje and RP Karandikar. The area of Tilak's Home Rule League was Maharashtra, Karnataka, Berar and Central Provinces, except Bombay. His slogan 'Swaraj is my birth right and I shall have it' became very famous among the people.

108. The longest river of peninsular India is

    A. Krishna   B. Kaveri

    C. Narmada   D. Godavari

Ans. D

Sol. The Godavari (1450 km) is the longest river of peninsular India, followed by Krishna (about 1300 km). It has the second largest river basin in India after the Ganges. It is often referred to as the Vridha (Old) Ganga or the Dakshina (South) Ganga.

109. Where is Jaldapara National Park located?

    A. Bihar   B. West Bengal

    C. Assam   D. Madhya Pradesh

Ans. B

Sol. Jaldapara National Park (formerly Jaldapara Wildlife Sanctuary) is a national park situated at the foothills of the Eastern Himalayas in Alipurduar District of northern West Bengal and on the banks of the Torsa River.

110. What is the tenure of the office of Comptroller and Auditor General of India (CAG):

    A. 5 years or age of 60, whichever is lower

    B. 6 years or age of 65, whichever is lower

    C. 4 years or age of 65, whichever is lower

    D. Age of 60 years.

Ans. B

Sol. According of DPC act of 1971. Terms of office for CAG are 6 Years or 65 years of age whichever is lower.

111. Who can remove the State Public Service Commissioner?

    A. They can be impeached by the state legislature

    B. Governor

    C. President

    D. Parliament

    E. None of the Above/More than one of the above

Ans. C

Sol. Though the state election commissioner is appointed by the Governor, he can be removed only by the President (and not by the governor). Thus, the correct answer is (C). They can

be removed on the same ground as the members of UPSC. Other than this, he/she can also be removed on other grounds like Misbehavior, for which matter should be referred to the Supreme Court. If stands guilty, the President should remove the person as the advice tendered is binding in nature.

112. Consider the following statements regarding the GDP of India:

1) Only the produce of resident citizens is considered.

2) Income earned by Indians residing in the USA is considered.

3) The produce of foreign nationals residing in Indian territory is considered.

4) The National Statistical Office (NSO) of the Government of India reports the GDP.

Which of the statements given above is/are correct?

A. 1 and 2 only
B. 3 and 4 only
C. 1, 2 and 4 only
D. 1, 2, 3 and 4

Ans. B

Sol. Gross Domestic Product is the total value of all final goods and services produced within the boundary of a country during a given period of time, generally one year. Here, produce of resident citizens as well as foreign nationals who reside within the geographical boundary of India is considered. A citizen of India working in USA may be earning her wage and it will be included in the USA GDP. The National Statistical Office (NSO) of the Government of India reports the GDP.

113. Which of the following is widely used as a macroeconomic indicator of inflation?

A. Wholesale Price Index (WPI)

B. Consumer Price Indices (CPI)

C. The Index of Industrial Production (IIP)

D. None of the above

Ans. B

Sol. Consumer Price Indices (CPI) measure changes over time in general level of prices of goods and services that households acquire for the purpose of consumption. CPI is widely used as a macroeconomic indicator of inflation, as a tool by governments and central banks for inflation targeting and for monitoring price stability, and as deflators in the national accounts. CPI is also used for indexing dearness allowance to employees for increase in prices.

114. The value of g at pole is

A. Greater than the value at the equator

B. Less than the value at the equator

C. Equal to the value at the equator

D. None of these

Ans. A

Sol.

115. Which of the following elements has the highest atomic radius?

A. Boron   B. Aluminium

C. Gallium   D. Indium

Ans. D

Sol. Indium has the highest atomic radius. Indium is a chemical element with symbol In and atomic number 49. It is a post-transition metal that makes up 0.21 parts per million of the Earth's crust. Very soft and malleable, indium has a melting point higher than sodium and gallium, but lower than lithium and tin.

116. Where are erythrocytes and leukocytes produced?

A. Lymph nodes   B. Bone marrow

C. Arterial walls   D. None of these

Ans. B

Sol. • Leukocytes are the white blood cells. They are the immune cells that protect our body from infection.

• Erythrocytes are red blood cells containing haemoglobin that impart red colour to blood and transport oxygen and carbon dioxide to and from tissues.

• Erythrocytes and leukocytes are produced in the bone marrow.

117. One of the model floriculture centres in India is located in _____ in Uttar Pradesh.

A. Lucknow   B. Prayagraj

C. Varanasi   D. Agra

Ans. A

Sol. One of the 9 model floriculture centres established in India one is in Lucknow. In Kannauj, perfumes are made from flowers. Flowers are cultivated in the districts of Varanasi, Kannauj, Mirzapur, Jaunpur, Allahabad, Lucknow, etc. Various types of grants are provided by the government for the nursery of flowers.

118. The correct sequence of the following districts of Uttar Pradesh from North to South is

A. Sant Kabir Nagar, Ambedkar Nagar, Siddharth Nagar, Sant Ravidas Nagar

B. Siddharth Nager, Sant Kabir Nagar, Ambedkar Nagar, Sant Ravidas Nagar

C. Ambedkar Nagar, Siddharth Nagar, Sant Ravidas Nagar, Sant Kabir Nagar

D. Sant RavidasNagar.Siddharth Nagar, Sant Kabir Nagar, Ambedkar Nagar

Ans. B

Sol. The current sequence of the following districts of Uttar Pradesh from North to South is: Siddharth Nager, Sant Kabir Nagar, Ambedkar Nagar, Sant Ravidas Nagar

119. When and by whom was the 'Sati Burj' constructed in Mathura?

A. Raja Mansingh, 1675   B. King Kalyan Chand, 1563

C. Bhagwan Das, king of Amer, 1570   D. Adi Shankara, 8th century

Ans. C

Sol. Sati Burj was built by Raja Bhagwan Das in 1570. This is a slender quadrangular tower of red sandstone commemorating the self-sacrifice of some faithful wives. It was built by the son of King Bihari Mal of Jaipur to commemorate his mother's demise who performed sati.

120. Who is not matched in the following pairs?

A. Todarmal - Sitapur

B. Abulphjal - Agra

C. Birbal - Kannauj

D. Jiauddin Barani - Bulandshahr

Ans. C

Sol. Birbal was born in 1528 as Mahesh Das, in a village near Kalpi.

121. Consider the following statements:

1. According to the ISFR 2019, the total recorded forest area in Uttar Pradesh is 18,582 square kilometres which is 8.88 % of the total geographical area.

2. Sonbhadra is the district with the maximum forest cover in Uttar Pradesh.

3. The forest cover in the state has increased by 126.65 sq km as compared to revised figures of ISFR 2017.

Of these statements,

A. only 1 and 2 are correct

B. only 2 and 3 are correct

C. only 3 and 1 are correct

D. 1, 2 and 3 are correct

Ans. B

Sol. Statement 1 is false. According to the ISFR 2019, the total recorded forest area in Uttar Pradesh is 16,582 square kilometres which is 6.88% of the total geographical area. As per statutory status, it has 72.79% of reserved forest, 6.98% protected forest and 20.23% unclassed forest.

Statement 2 is true. Sonbhadra is the district with the maximum forest cover in Uttar Pradesh. Statement 3 is true. The forest cover in the state has increased by 126.65 sq km as compared to revised figures of ISFR 2017.

122. For the following questions

Find the odd word/letter/number pair from the given alternatives

A. 14, 12

B. 24, 7

C. 42, 4

D. 37, 4

Ans. D

Sol. We find that each pair can be related as

14*12=168

24*7=168

42*4=168

37*4=148 But this does not lead to 168 and hence this is the odd one out.

Hence D

123. Two statements are given, followed by three conclusions numbered I, II and III. Assuming the statements to be true, even if they seem to be at variance with commonly known facts, decide which of the conclusion logically follow(s) from the statements.
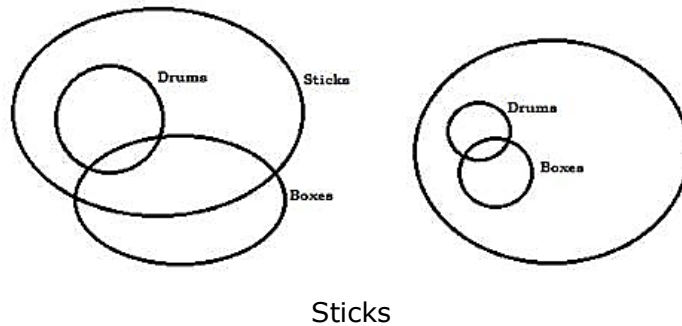
Statements:

All drums are sticks.

Some drums are boxes.

Conclusions:

I. Some boxes are sticks.

II. Some sticks are drums.

III. All sticks are drums.

A. Only conclusions I and II follow

B. Only conclusions I and III follow.

C. Only conclusions II and III follow

D. All the conclusions, I, II and III follow

Ans. A

Sol.

Sticks

From the above diagrams , it is clear that only conclusion I and II follows.

Hence, option (A) is the correct answer.

124. How many days will 1648 people take to construct a dam, if 721 people can build the same in 48 days?

A. 21 days   B. 20 days

C. 22 days   D. 19 days

Ans. A

Sol.   Let 1648 people can construct a dam in x days.

Given M_1=1648, M_2=721

D_1=x days , D_2=48 days

∴ $M_1 D_1 = M_2 D_2$

⇒ 1648 × x = 721 × 48

⇒ x = (721×48)/1648 = 21 days

125. A sold a watch to B at a profit of 20%. B sold it to C at 30% profit. C sold it to D at 10% loss. If B's profit is Rs. 80 more than that of A, then D bought it for:

A. Rs. 700   B. Rs. 680

C. Rs. 652   D. Rs. 702

Ans. D

Sol.   Let the cost price of watch for A be 100x.

Then, selling price for A (or cost price for B) = 100x + (100x) × 20%

= 100x + 20x = 120x

Selling price for B (or cost price for C) = 120x + (120x) × 30%

= 120x + 36x = 156x

Selling price for C (or cost price for D) = 156x – (156x) × 10%

= 156x – 15.6x = 140.4x

Now, as per question,

Profit of B – Profit of A = Rs. 80

⇒ (156x – 120x) – (120x – 100x) = 80

⇒ 36x – 20x = 80

⇒ 16x = 80

⇒ x = 5

Therefore, D bought the watch for 140.4x = 140.4 × 5 = Rs. 702

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