DETAILED SOLUTIONS

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ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

MECHANICAL ENGINEERING

Test 4

Section A : Production Engineering & Material Science [All Topics]
Section B : Thermodynamics-1 [Part Syllabus]
Section C : Refrigeration and Air-Conditioning-1 [Part Syllabus]

1.	(c)	16.	(b)	31.	(c)	46.	(b)	61.	(c)
2.	(c)	17.	(b)	32.	(d)	47.	(c)	62.	(b)
3.	(b)	18.	(b)	33.	(d)	48.	(c)	63.	(c)
4.	(d)	19.	(b)	34.	(c)	49.	(b)	64.	(d)
5.	(d)	20.	(c)	35.	(b)	50.	(d)	65.	(d)
6.	(c)	21.	(d)	36.	(a)	51.	(a)	66.	(a)
7.	(a)	22.	(c)	37.	(b)	52.	(d)	67.	(b)
8.	(d)	23.	(b)	38.	(d)	53.	(b)	68.	(d)
9.	(b)	24.	(c)	39.	(b)	54.	(a)	69.	(a)
10.	(a)	25.	(d)	40.	(c)	55.	(c)	70.	(a)
11.	(b)	26.	(a)	41.	(b)	56.	(d)	71.	(c)
12.	(c)	27.	(d)	42.	(a)	57.	(d)	72.	(d)
13.	(d)	28.	(b)	43.	(d)	58.	(a)	73.	(c)
14.	(d)	29.	(b)	44.	(d)	59.	(c)	74.	(d)
15.	(c)	30.	(b)	45.	(a)	60.	(c)	75.	(d)

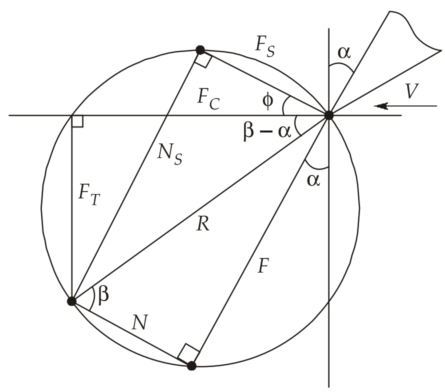
DETAILED EXPLANATIONS

1. (c)

- Continuous chips are the most desirable form of chips since the surface finish obtained is good and cutting is smooth. These chips are formed because of the ductility of metal.
- Since the cutting is carried by the BUE and not the actual tool tip, the life of the cutting tool increases while cutting with BUE. In this way, BUE is not harmful during rough machining.

2. (c)

Given, $\alpha = 10°$, $\beta = 62°$, $\phi = 19°$, $F_C = 1650$ N



From Merchant's circle, the resultant cutting force is

$$R = \frac{F_c}{\cos(\beta - \alpha)} = \frac{1650}{\cos 52°} = \frac{1650}{0.6} = 2750 \text{ N}$$

3. (b)

Coefficient of friction is given by,

$$\mu = \tan\beta = \tan 62° = 1.9$$

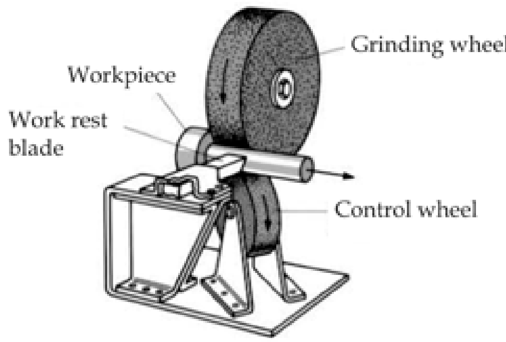
4. (d)

From Merchant's circle, shear force is given by,

$$F_S = R\cos[\phi + (\beta - \alpha)]$$
$$= 2750\cos[19° + 62° - 10°]$$
$$= 2750 \times 0.3 = 825 \text{ N}$$

5. (d)

- In centreless grinding operation, the grinding wheel and regulating wheel are not in the plane as shown in figure below. The regulating wheel is mounted at an angle to the plane of the grinding wheel.



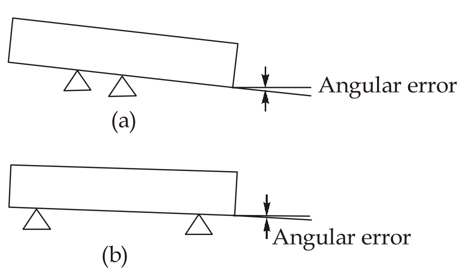
- Backing up the workpiece by the regulating wheel and work rest blade practically eliminates any deflection of the workpiece. This permits maximum material removal rates.

6. (c)

- The dielectric fluid should have sufficient and stable dielectric strength to serve as insulation between the tool and work till the breakdown voltage is reached.
- It should have low viscosity to provide effective cooling mechanism and remove the swarf particles from the machining gap.
- Flash point is the lowest temperature at which a dielectric gives off sufficient vapours to produce an inflammable mixture of air and gases in a standarized apparatus. The highest the flash point, the better it is for use in EDM.
- Dielectrics should have low specific gravity. The heavier chips settle down in the lighter dielectric reducing the gap contamination and possibilities of secondary discharge and/or arcing.
- It should be chemically neutral so as not to attack the electrode, the workpiece, the table or the tank.

7. (a)

Wear of any locator contributes less to the inaccuracy of location if the locators are placed far apart. This can be examined as shown in figure below. In figure (a) the two locators are too close, and thus due to small unequal wear on one locator a large error is caused. When the locators are moved apart as in figure (b), the possible error gets minimized.



The effect of positioning the locators apart on a given surface

8. (d)

Type of fit for given hole basis arrangement:

- H7h6 – Clearance fit
- H7d10 – Clearance fit
- H7k6 – Transition fit
- H7s6 – Interference fit

Since pulley mounted on a shaft is assembled with interference fit, the correct option is H7s6.

9. (b)

Smallest division on main scale = 0.5 mm

The thimble is divided into 50 divisions.

Thus, $$\text{least count} = \frac{0.5}{50} = 0.01 \text{ mm}$$

$$\text{Micrometer reading} = 10.50 + 16 \times 0.01 = 10.66 \text{ mm}$$

10. (a)

The default or turn on codes in operation of an NC machine tool are following:

- G00 – rapid positioning
- G17 – XY plane selection
- G40 – Cutter compensation, cancel
- G70 – Inch units
- G90 – Absolute coordinate system

12. (c)

- In the substitutional solid solutions, the solute atoms would replace the solvent atoms. This is only possible if both the atoms are similar in size and also in nature.
- In an interstitial solid solution, the solute atom would be positioned in the interstitial sites formed by the solvent atoms. It is possible only when the solvent atom is much larger compared to the solute atom.

13. (d)

Iron forms iron sulphide (FeS) with sulphur, which solidifies along the grain boundaries making the steel brittle. If equal amount of manganese is present in the steel than manganese sulphide, MnS, forms and harmful effects of sulphur are reduced. It is generally recommended that manganese should be at least 3 times that of sulphur.

15. (c)

- The main purpose of using chaplet is to support the cores. For directional solidification chills and paddings are primarily used, although chaplets can promote directional solidification but it is not their main purpose.
- If the unsupported load on core is less than or equal to zero, no chaplet is required. But if it is greater than zero than the chaplet area required is 29 mm^2 for every Newton of unsupported load.

16. (b)

The metallostatic force comes because of the head with which the metal is entering the mould cavity.

$$\text{Head of the metal, } h - c = 10\text{ cm} - 1\text{ cm} = 9\text{ cm}$$

Area on which the metal pressure will be acting,

$$A_p = 100\text{ cm}^2$$

$$\text{Metallostatic force, } F_m = A_p \rho_m (h - c)$$

$$= 100 \times 0.07 \times 0.9 = 63\text{ N}$$

17. (b)

A cold shut is caused when two metal streams, while meeting in the mould cavity, do not fuse together properly thus causing a discontinuity or weak spot. These defects are caused essentially by the lower fluidity of the molten metal or that the section thickness of the casting is too small.

18. (b)

Stresses Induced	Operations
Shearing	Shearing, blanking, piercing, trimming, shaving, notching, nibbling
Tension	Stretch forming
Compression	Coining, sizing, ironing, hobbing
Tension and compression	Drawing, spinning, bending, forming, embossing

19. (b)

- Higher temperature of metal in hot working can lead to possibility of decarburisation of skin in steels.
- Since the shear stress gets reduced at higher temperatures, hot working requires much less force to achieve the necessary deformation.
- Even brittle materials can gain some ductility at high temperatures. Hence they can be hot worked.

20. (c)

Given :

$$\text{Die opening factor, } k = 1.5$$

$$\text{Sheet thickness, } t = 3\text{ mm}$$

$$\text{Width of die opening, } W = 6t = 18\text{ mm}$$

$$\text{Ultimate tensile strength, } \sigma_{ut} = 400\text{ MPa}$$

$$\text{Bend length, } L = 1500\text{ mm}$$

$$\text{Bending force, } F = \frac{kL\sigma_{ut}t^2}{W}$$

$$= \frac{1.5 \times 1500 \times 400 \times 3^2}{18}$$

$$= 450000\text{ N} = 450\text{ kN}$$

21. (d)

- In case of constant current arc welding machine, for a large change in output voltage, the corresponding change in current is so small that the quality of the weld can be maintained. This is very essential for manual arc welding processes since the maintenance of constant arc is nearly impossible by a human welder.
- In case of constant voltage welding machines, the curve is so flat, that any small change in voltage makes for an extremely large change in the output currents. These systems are generally preferred in the automatic machines since they become self-corrective.

22. (c)

- Al and its alloys possess good electrical conductivity and hence are not similar to semiconductor.
- As Al has FCC crystal structure, these alloys are ductile even at low temperatures and can be formed easily.
- The limitation with Al and its alloys is their melting point which restricts their use at elevated temperatures.

23. (b)

Since the pressure is taken as atmospheric, the Gibb's phase rule can be modified for this system as

$$P + F = C + 1$$

$$\Rightarrow \quad C = P + F - 1$$

For number of components (C) to be minimum, degree of freedom (F) should be zero.

$$\therefore \quad C = P - 1$$

Now, since four phases exist at equilibrium

$$P = 4$$

Thus, $$C = 3$$

Note : For a single component system i.e. $C = 1$, the maximum number of phases that can co-exist is three.

24. (c)

During tempering, the metastable martensite decomposes into the more stable products of ferrite and cementite by the process of carbon diffusion.

25. (d)

Polishing the surface of the component to a good finish removes some of the surface irregulaties, which may initiate a crack. Shot peening of metals introduce compressive stresses at the surface and improves the fatigue strength. Carburizing and nitriding introduce strong layers and increase the resistance to crack initiation at the surface. On the other hand, decarburization produces a soft surface layer that lowers the fatigue resistance. A fine grain size improves the fatigue resistance.

27. (d)

Yield strength of a polycrystalline material, according to Hall-Petch equation, is given by

$$\sigma_y = \sigma_i + \frac{k}{\sqrt{d}}$$

where, σ_i : yield stress for the material if there are no grain boundaries.

For σ_1 = 120 MPa, d_1 = 0.04 mm

$$120 = \sigma_i + \frac{k}{\sqrt{0.04}}$$

$$\Rightarrow \quad 120 - \sigma_i = \frac{k}{\sqrt{0.04}}$$

$$\Rightarrow \quad k = (120 - \sigma_i) \times \sqrt{0.04} \quad \text{...(i)}$$

For $\sigma_2 = 220$ MPa, $d_2 = 0.01$ mm

$$220 = \sigma_i + \frac{k}{\sqrt{0.01}}$$

$$\Rightarrow \quad 220 - \sigma_i = \frac{k}{\sqrt{0.01}}$$

$$\Rightarrow \quad k = (220 - \sigma_i) \times \sqrt{0.01} \quad \text{...(ii)}$$

From equation (i) and (ii),

$$\sqrt{0.01}(220 - \sigma_i) = \sqrt{0.04}(120 - \sigma_i)$$

$$220 - \sigma_i = 2(120 - \sigma_i)$$

$$\sigma_i = 240 - 220 = 20 \text{ MPa}$$

28. (b)

Dow metal is an alloy of magnesium. It contains nearly 90% Mg, 10% Al and small amounts of Manganese. It finds applications in automobile and aircraft industries. It is extremely light and possess good weldability and machinability.

29. (b)

Cementite (Fe_3C) with 6.67%C has orthorhombic crystal structure. The lattice parameters of orthorhombic crystal structure are related as $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90°$.

30. (b)

When the load is applied parallel to the fibres, the elastic strain ε is the same in both the fibres and the matrix. If σ_f and σ_m are the stresses in the fibres and the matrix,

$$E_f = \frac{\sigma_f}{\varepsilon_f}, \; E_m = \frac{\sigma_m}{\varepsilon_m}$$

Since, $\varepsilon_f = \varepsilon_m$

$$\frac{E_f}{E_m} = \frac{\sigma_f}{\sigma_m} = \frac{440}{71} = 6.2 \quad \text{...(i)}$$

Also, $0.3\sigma_f + 0.7\sigma_m = \sigma$

$$0.3\sigma_f + 0.7\sigma_m = \frac{100}{1}$$

$$\sigma_m = \frac{100 - 0.3\sigma_f}{0.7}$$

$$\sigma_m = 143 - 0.43\sigma_f \quad \text{...(ii)}$$

From equations (i) and (ii),

$$\frac{\sigma_f}{143 - 0.43\sigma_f} = 6.2$$

$$\sigma_f = 242 \text{ MPa}$$

When the load is applied perpendicular to the fibres, the stress in the fibre and the matrix is the same i.e. 100 MPa. Thus, the required ratio is 2.42.

31. (c)

Superalloys exhibit excellent mechanical strength and resistance to creep at high temperatures, good surface stability, and corrosion and oxidation resistance.

34. (c)

The creep rate is constant during secondary creep stage which occurs at the middle portion of creep curve.

35. (b)

The heat generated in resistance welding is only because of the welding joint. Hence the connecting wires do not contribute to the resistance.

38. (d)

- Macroscopic or classical or phenomenological approach focusses on the observable properties of a finite quantity of matter disregarding the atomistic structure.
- Microscopic or statistical approach is concerned directly with the structure of matter. It relates to the behaviour of an accepted model of its atomistic sub-structure.

39. (b)

$$T = A\ln P + B$$

At $T = 0°C$;

$$0 = A \times \ln 2 + B$$

$\Rightarrow$

$$B = -A\ln 2 \quad \text{...(i)}$$

At $T = 100°C$;

$$100 = A \times \ln 7 + B \quad \text{...(ii)}$$

From equation (i) and (ii), we get

$$100 = A \times \ln 7 - A \times \ln 2$$

$\Rightarrow$

$$A = \frac{100}{\ln\left(\frac{7}{2}\right)}$$

$$A = 79.8235 \text{ and } B = -55.3294$$

$$T = 79.8232 \times \ln(3) + (-55.3294) = 32.36°C$$

40. (c)

Given : $U_1 = 830$ kJ; $W = -120$ kJ; $Q = -450$ kJ

From first law of thermodynamics,

$$Q = \Delta U + W$$

$$= (U_2 - U_1) + W$$

$\Rightarrow$

$$U_2 = -450 - (-120) + 830$$

$$= 500 \text{ kJ}$$

41. (b)

A mixture of two or more phases of a substance is still a pure substances as long as the chemical composition of all phases is the same. Example : A mixture of ice and liquid water is a pure substance because both phases have the same chemical composition.

A mixture of liquid air and gaseous air is not a pure substance since the composition of liquid air is different from the composition of gaseous air, and thus the mixture is no longer chemically homogeneous. This is due to different components in air condensing at different temperatures at a specified pressure.

42. (a)

Work done by the stirring device upon the system,

$$W_s = 2\pi TN$$
$$W_s = 2\pi \times 1.3 \times 10^{-3} \times 12000$$
$$= 98.017 \simeq 98.02 \text{ kJ}$$

Stirring work for the system is negative.

Work done by the system upon the surrounding,

$$W_d = pAL$$
$$W_d = 101.3 \times \frac{\pi}{4} \times 0.7^2 \times 0.8$$
$$= 31.188 \simeq 31.19 \text{ kJ}$$

Displacement work is positive work for the system.

$\therefore$ The net work transfer for the system,

$$W_{net} = W_s + W_d = -98.02 + 31.19$$
$$= -66.83 \text{ kJ}$$

43. (d)

For the expansion process:

$$P_1V_1^n = P_2V_2^n = P_3V_3^n$$

$\therefore$
$$n = \frac{\ln\left(\frac{P_1}{P_2}\right)}{\ln\left(\frac{V_2}{V_1}\right)} = \frac{\ln\left(\frac{200}{70.71}\right)}{\ln\left(\frac{0.4}{0.2}\right)} = 1.5$$

or
$$n = \frac{\ln\left(\frac{P_2}{P_3}\right)}{\ln\left(\frac{V_3}{V_2}\right)} = \frac{\ln\left(\frac{70.71}{24.999}\right)}{\ln\left(\frac{0.8}{0.4}\right)} = 1.5$$

44. (d)

Given : $Q_1 = 235$ J at $T_1 = 373.15$ K; $T_2 = 273.16$ K

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

$$\Rightarrow \quad Q_2 = Q_1 \times \frac{T_2}{T_1} = 235 \times \frac{273.16}{373.15}$$

$$Q_2 = 172.03 \text{ J}$$

$$\therefore \quad W = Q_1 - Q_2$$

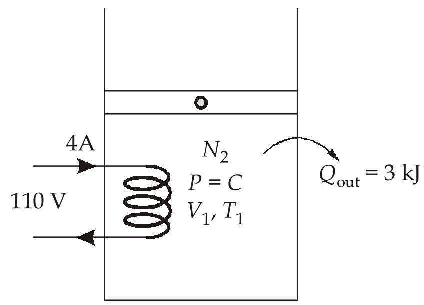
$$= 235 - 172.03$$

$$= 62.97 \text{ J}$$

45. (a)

Given : V = 110 V; I = 4A; t = 3 minutes; P_1 = 300 kPa; V_1 = 0.8 m^3; T_1 = 300 K

C_p = 1.039 kJ/kgK; Q_{out} = 3000 J = 3 kJ



The electrical work done on the nitrogen,

$$W_{e,\text{in}} = VIt$$

$$= \frac{110 \times 4 \times (3 \times 60)}{1000} = 79.2 \text{ kJ}$$

The mass of nitrogen gas in the device,

$$m = \frac{P_1V_1}{RT_1} = \frac{300 \times 0.8}{\left(\frac{8.314}{28}\right) \times 300} = 2.694 \text{ kg}$$

The energy balance on the system can be expressed as

$$\underbrace{E_{\text{in}} - E_{\text{out}}}_{\substack{\text{Net energy transfer by} \\ \text{heat, work and mass}}} = \underbrace{\Delta E_{\text{system}}}_{\substack{\text{Change in internal, kinetic,} \\ \text{potential, etc. energies}}}$$

$$\Rightarrow \quad W_{e,\text{in}} - Q_{\text{out}} - W_{b,\text{out}} = \Delta U$$

$$\Rightarrow \quad W_{e,\text{in}} - Q_{\text{out}} = \Delta H$$

$$= m(h_2 - h_1) = mC_p(T_2 - T_1)$$

Note : $\Delta U + W_b \equiv \Delta H$ for closed system undergoing a quasi-equilibrium expansion or compression process at constant pressure.

$$79.2 - 3 = 2.694 \times 1.039 \times (T_2 - 27)$$

$$T_2 = 54.22°\text{C}$$

46. (b)

Given : T_1 = 17°C = 17 + 273 + 290 K; P_1 = 123.11 kPa; D_1 = 70 cm = 0.70 m; h_1 = 290.16 kJ/kg

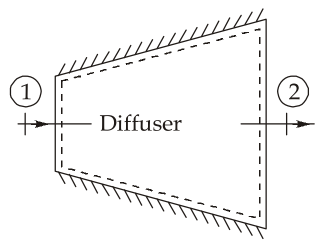
Mass flow rate of the air through the diffuser,

$$\dot{m} = \rho \cdot A \cdot V_1 = \frac{P}{RT_1} \times A \times V_1$$

$$\dot{m} = \frac{123.11}{0.287 \times 290} \times \frac{\pi}{4} \times 0.7^2 \times 220$$

$$= 125.234 \text{ kg/s}$$

47. (c)



Applying steady flow energy equation, we get

$$h_1 + \frac{V_1^2}{2} + \cancel{gz_1}^{0} + \cancel{q_{cv}}^{0} = h_2 + \cancel{\frac{V_2^2}{2}}^{0} + \cancel{gz_2}^{0} + \cancel{w_{cv}}^{0}$$

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

$$= 290.16 + \frac{220^2}{2 \times 1000} = 314.36 \text{ kJ/kg}$$

48. (c)

- Throttling valve is a kind of flow restricting device that cause a significant pressure drop in the fluid.
- The pressure drop in the fluid is often accompanied by a large drop in temperature except for an ideal gas and for that reason throttling devices are commonly used refrigeration and air-conditioning applications.

49. (b)

The difference between the entropy change of a closed system.

$$\Delta S_{sys} = S_2 - S_1 = \int_1^2 \frac{\delta Q}{T} + S_{gen}$$

For an isolated system or simply an adiabatic closed system, the heat transfer is zero, thus the above equation reduces to

$$\Delta S \geq 0$$

Since, the entropy generation S_{gen} is always a positive quantity or zero.

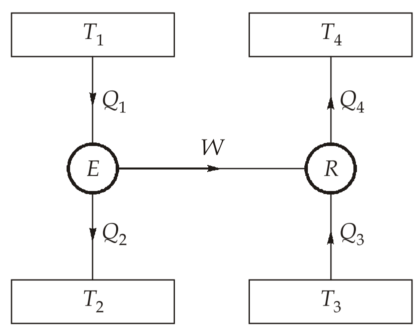
50. (d)

- The processes can occur in a certain direction only, not is any direction. A process must proceed in the direction that complies with the increase of entropy principle.
- Entropy is non-conserved property, and there is no such thing as the conservation of entropy principle.
- Entropy generation is a measure of the magnitudes of the irreversibilities present during that process. The greater the extent of irreversibilities, the greater the entropy generation.

52. (d)

The moving boundary work associated with real engines or compressors cannot be determined exactly from a thermodynamic analysis alone because the piston usually moves at very high speeds, making it difficult for the gas inside to maintain equilibrium.

53. (b)



$$\text{COP}_R = 4$$

$$\Rightarrow \quad \frac{Q_3}{W} = 4$$

$$\Rightarrow \quad W = \frac{1000}{4} = 250 \text{ kJ}$$

$$\eta_{HE} = \frac{W}{Q_1}$$

$$\Rightarrow \quad Q_1 = \frac{250}{0.4} = 625 \text{ kJ}$$

54. (a)

$$\eta_{HE} = \frac{W}{Q_1}$$

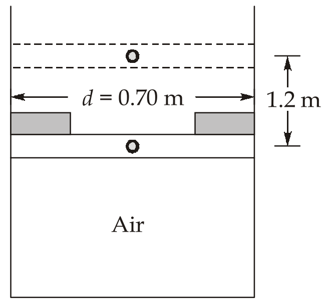
$$\Rightarrow \quad W = 1000 \times 0.4 = 400 \text{ kJ}$$

$$\text{COP}_{HP} = \frac{Q_4}{W}$$

$$\Rightarrow \quad Q_4 = W \times \text{COP}_{HP} = 400 \times 5 \quad [\because \text{COP}_{HP} = 1 + \text{COP}_{ref} = 1 + 4 = 5]$$

$$= 2000 \text{ kJ} = 2 \text{ MJ}$$

55. (c)



$$V_2 = V_1 + \Delta V$$

$$= 0.1 + \frac{\pi}{4} \times d^2 \times \Delta x$$

$$= 0.1 + \frac{\pi}{4} \times 0.7^2 \times 1.2 = 0.562 \text{ m}^3$$

$$P_2 = P_1 \times \left(\frac{V_1}{V_2}\right)^n = 1000 \times \left(\frac{0.1}{0.562}\right)^{1.5} = \frac{1000}{13.32} = 75.1 \text{ kPa}$$

∴ Work done by the gas during expansion,

$$W = \frac{P_1V_1 - P_2V_2}{n-1} = \frac{1000 \times 0.1 - 75.1 \times 0.562}{1.5 - 1}$$

$$= 115.59 \text{ kJ}$$

56. (d)

$$W = mgh + \frac{1}{2} \times mC^2 + P_0 \Delta V$$

$$\Rightarrow \quad 115.59 = \frac{80 \times 9.81 \times 1.2}{1000} + \frac{1}{2} \times 80 \times 10^{-3} \times C^2 + 100 \times (0.562 - 0.1)$$

$$C = 41.37 \text{ m/s}$$

57. (d)

Air cooled condenser is limited to smaller units such as domestic refrigerators and small water-coolers which uses vertical wire tube or plate and tube.

58. (a)

The vortex tube has low COP, limited capacity and only a small portion of the compressed air appearing as the cold air limits its wide use in practice.

59. (c)

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

Now,

$$T_1 = 47 + 273 = 320 \text{ K}$$

$$T_2 = -33 + 273 = 240 \text{ K}$$

$$\therefore \qquad COP = \frac{240}{320-240} = 3$$

Also, $$COP = \frac{Q_2}{W}$$

$$\therefore \qquad \dot{W} = \frac{10 \times 211 \times 60}{3} = 42200 \text{ kJ/h}$$

$$\therefore \qquad \text{Heat rejected, } Q_1 = \text{R.E.} + \dot{W}$$

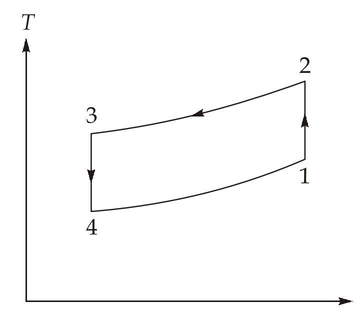
$$= 42200 + 10 \times 211 \times 60 = 168800 \text{ kJ/h}$$

60. (c)

In air-refrigeration, the COP is very poor and more power is required to Cope the cooling load.

61. (c)

Here, refer figure,



$$T_1 = 10 + 273 = 283 \text{ K}$$

$$T_2 = 177 + 273 = 450 \text{ K}$$

$$T_3 = 27 + 273 = 300 \text{ K}$$

and $$T_4 = 190 \text{ K}$$

$$\therefore \qquad \text{Refrigerating effect} \times \dot{m}_{ref} = \text{R.C.}$$

$$c_p(T_1 - T_4) \times \dot{m}_{ref} = 10 \times 211$$

$$\therefore \qquad \dot{m}_{ref} = \frac{10 \times 211}{1.005(283-190)} = 22.57 \text{ kg/min}$$

62. (b)

Compressor displacement is given by,

$$V_1 = \frac{\dot{m}_{ref} \times R \times T_1}{P_1}$$

$$= \frac{22.57}{60} \times \frac{0.287 \times 283}{100} = 0.305 \text{ m}^3\text{/sec}$$

63. (c)

$$COP = \frac{T_1 - T_4}{(T_2 - T_1) - (T_3 - T_4)}$$

$$COP = \frac{283 - 190}{(450 - 283) - (300 - 190)} = 1.63$$

65. (d)

When the high pressure liquid refrigerant from the condenser passes through the expansion valve, it gets evaporated partially. This partial evaporation of the liquid refrigerant is known as flash. This formed vapour, which cannot produce any refrigerating effect, is bypassed around the evaporator and supplied directly to the compressor through a flash chamber. The flash chamber is located between the evaporator and expansion valve.

66. (a)

- Primary refrigerants directly remove heat from the object/space ot be cooled, by evaporation in a vapour compression system.
- Secondary refrigerants carry refrigeration from the plant room to the space where it is to be usefully applied.
- Room air conditioner produces a refrigeration at a higher temperature of about 5°C whereas domestic refrigerator produces refrigeration at about –25°C. Since the heat rejection temperature will be same for both. Hence COP of domestic air conditioner as compared to that of domestic refrigerator will be higher.

68. (d)

There should be a large difference in the normal boiling points of the refrigerants and the absorbent. The refrigerant typical has a low boiling point to absorb heat and evaporate easily. While the absorbent has a higher boiler point to facilitate the separation of absorbed heat in the absorption cycle.

69. (a)

The ammonia is used as a refrigerant because it possesses most of the desirable properties. Through it is toxic and not otherwise preferred in domestic appliances, it is very safe in this system due to absence of any moving parts in the system and therefore, there is the least chance of any leakage. In electrolux refrigeration system, ammonia is refrigerant, water is solvent and hydrogen is used as an inert gas to increase the rate of evaporation of ammonia.

70. (a)

In steam jet refrigeration system, since the ejected vapour and motive steam condenses in the condenser, the magnitude of heat transfer is about three to four times that needed in the VCRS system per tonne per hour. Thus, large size condenser is needed.

71. (c)

The general chemical formula for a compound derived from a saturated hydrocarbon is given as:

$C_aH_bF_cCl_d$

The complete designation of the refrigerant is

$R(a-1)(b+1)c$

We have, R290 and on comparing, we get

$$a - 1 = 2 \Rightarrow a = 3$$

$$b + 1 = 9 \Rightarrow b = 8$$

and $$c = 0, \quad d = 0$$

$\therefore$ Chemical formula is C_3H_8.

73. (c)

$$\text{Piston displacement, } \dot{V}_s = \frac{\pi}{4}D^2L \times \frac{N}{60} = \dot{m}v_1$$

$$\dot{V}_s = \frac{\pi}{4} \times 0.1^2 \times 0.08 \times \frac{1200}{60} = \dot{m} \times 0.04$$

On solving, we get

$$\dot{m} = 0.314 \text{ kg/s}$$

74. (d)

$$\text{Power input, } P = \frac{\dot{m}(h_2 - h_1)}{3.5}$$

$$= \frac{0.314(210 - 180)}{3.5} = 2.7 \text{ kW}$$

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