IPD PPD Solved Problems and Answered Elements
(September 2013)

INSTRUCTION: Select the correct answer for each of the following questions. Mark only one answer for each item by shading the box corresponding to the letter of your choice on the answer sheet provided. STRICTLY NO ERASURES ALLOWED. Use pencil No. 1 only

1. A 300 MW coal-fired power plant operates for 6000 hours per year. If the over-all efficiency is 40 % and considering a fuel cost of P52.8 per million Btu (MMBtu), determine the approximate fuel cost of the said plant.

a) P8.11 x 10^{14} b) P811.0 x 10^{14} c) P81.1 x 10^{14} d) P8.11 x 10^{13}

Solution: Heat Rate, $HR = \frac{3413}{e_{th}} = \frac{3413}{0.40} = 8532.5 \text{ Btu/kW}\cdot\text{Hr}$ Annual Cost,

$$AC = (1000)(MW)(HR)\left(\frac{Hr}{Year}\right)(\text{Cost of Fuel})$$

$$AC = (1000)(300\text{ MW})(8532.5\text{ Btu/kW}\cdot\text{Hr})(6000\text{ Hrs/year})\left(\frac{P52.8}{1000\,000\text{ Btu}}\right) = P8.11 \times 10^{14}\text{ per year}$$

Answer: a) P8.11 x 10^{14}

2. Hot water at 1000 psia and 390 °F (v = 0.0185 Ft^3/lb) flows at 50 000 lb/hr. Calculate its volume flow rate in gpm.

a) 114.5 gpm **b) 115.41 gpm** c) 151.41 gpm d) 141.5 gpm

Solution: $V_T = (50\,000\text{ lb/hr})(0.0185\text{ ft}^3/\text{lb})(7.4863\text{ gal/ft}^3)(1\text{ hr}/60\text{ min}) = 115.41\text{ gpm}$

Answer: b) 115.41 gpm

3. Water at 8 °C (h_f = 33.60 kJ/kg) enters a jet condenser and discharges it at 37 °C (h_f = 155.03 kJ/kg). Condenser pressure is 76.2 mm Hg abs (h_f = 191.83 kJ/kg, h_g = 2584.7 kJ/kg). Calculate the mass of condensing water per kg of exhaust steam with a quality of 88 %

a) 16.74 **b) 17.64** c) 14.64 d) 16.47

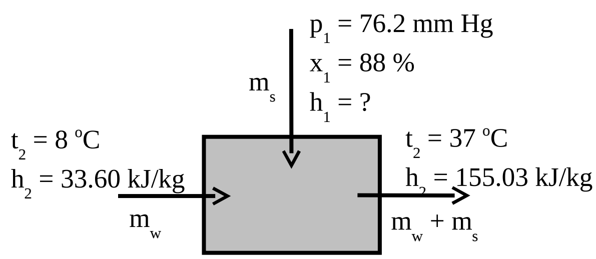
Solution: $h_1 = h_{f1} + x_1(h_{g1} - h_{f1}) = 191.83 + (0.88)(2584.7 - 191.83) = 2297.56\text{ kJ/kg}$

Heat balance, $m_w h_2 + m_s h_1 = (m_w + m_s)h_3 = m_w h_3 + m_s h_3$

$$\frac{m_w}{m_s} = \frac{h_1 - h_3}{h_3 - h_2} = \frac{2297.5 - 155.03}{155.03 - 33.60} = 17.64\text{ kg/kg}$$

Note: In jet condenser, the exhaust steam mixes with cooling water.

Answer: b) 17.64



4. 220lps of cooling water at 0 °C enters a surface condenser and leaves at 12 °C. Compute for the heat absorbed by the cooling water if the condenser has cooling surface of 244.5 m^2.

a) 11 350.68 kJ/s b) 11 530.68 kJ/s c) 11 680.35 kJ/s **d) 11 053.68 kJ/s**

Solution: $q_c = q_w = mc_p(\Delta T) = (220\text{ kg/s})(4.187\text{ kJ/kg}\cdot\text{K})(12 - 0) = 11053.68\text{ kJ/s}$

Where, $m = (220\text{ lps})(1\text{ kg/li}) = 220\text{ kg/s}$

Answer: d) 11 053.68 kJ/s

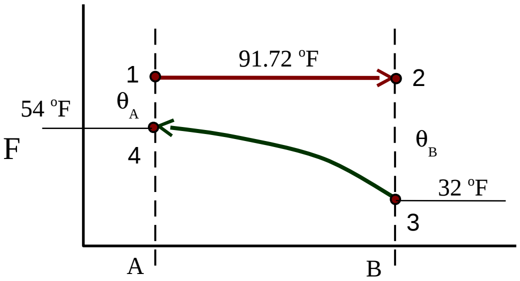
5. 3475 gpm of cooling water at 32 °F enters a surface condenser and leaves at 54 °F. The condenser pressure is 1.5" Hg with condensate temperature of 91.72 °F. Determine the log-mean temperature difference between steam and cooling water.

a) 48.87 °F b) 48.78 °F **c) 47.88 °F** d) 46.88 °F

Solution: $\theta_A = t_1 - t_4 = 91.72 - 54 = 37.72$ °F = θ_{min}

$\theta_B = t_2 - t_3 = 91.72 - 32 = 59.72$ °F = θ_{max}

$$LMTD = \frac{\theta_{max} - \theta_{min}}{\ln\left(\frac{\theta_{max}}{\theta_{min}}\right)} = \frac{59.72 - 37.72}{\ln\left(\frac{59.72}{37.72}\right)} = 47.88\ ^oF$$



Answer: c) 47.88 °F

6. Convert 8 500 lb/hr of standard air to cfm.
a) 1889 b) 8198 c) 1898 d) 1988

Solution: At standard air means air at standard condition, at 70 °F and 14.7 psia where $\rho_a = 0.075$ lb/ft^3.

$$Q = \frac{m}{\rho_a} = \frac{(8500\ lb/hr)\left(\frac{1\ hr}{60\ min}\right)}{0.075\ lb/ft^3} = 1888.89\ cfm$$

Answer: a) 1889 cfm

7. The ultimate analysis of coal as-fired is as follows: C = 65.65 %; O = 18.61%; M = 3%; H = 5.87%; S = 1.51%; Ash = 5.36%. It is required to find the theoretical volume of air at 21°C and 101.3 kPa absolute pressure to burn one kilogram of coal.
a. 9.43 m^3_{air}/kg_{coal} **b. 7.36 m^3_{air}/kg_{coal}** c. 8.43 m^3_{air}/kg_{coal} d. 6.43 m^3_{air}/kg_{coal}

Solution:

$$W_a = 11.5C + 34.5\left(H_2 - \frac{O_2}{8}\right) + 4.32S = 11.5(0.6565) + 34.5\left(0.0587 - \frac{0.1861}{8}\right) + 4.32(0.0151) = 8.8376\ kg/kg$$

Theoretical Volume of air, $$V_a = \frac{W_a RT}{p_a} = \frac{8.8376(0.28708)(21+273)}{101.3} = 7.36\ m^3/kg$$

Answer: b) 7.36 m^3 air per kg fuel

8. What is the density of a fuel at 25°C if it has a heating value of 43,000 kJ/kg?
a. 840 kg/m^3 b. 873 kg/m^3 **c. 970 kg/m^3** d. 940 kg/m^3

Solution: $HHV = 41130 + 139.6(^o API)$ $$^o API = \frac{HHV - 41130}{139.6} = \frac{43000 - 41130}{139.6} = 13.4$$

$$SG_o = \frac{141.5}{^o API + 131.5} = \frac{141.5}{13.4 + 131.5} = 0.9765 \qquad \rho_o = 976.5\ kg/m^3$$

$$\rho_t = \frac{\rho_o}{1 + 0.0007(t - t_o)} = \frac{976.5}{1 + 0.0007(25 - 15.56)} = 970.12\ kg/m^3$$

Solution: c) 970 kg/m^3

9. Determine the volume flow rate of air at the following conditions: 40 psia and 280 °F. Its volume flow rate at standard condition is 2500 cfm.

a) 1823 Cfm **b) 1283 cfm** c) 1382 cfm d) 1832 cfm

Solution: $$MR = \frac{p_1Q_1}{T_1} = \frac{p_2Q_2}{T_2} \qquad Q_2 = Q_1\left(\frac{p_1}{p_2}\right)\left(\frac{T_2}{T_1}\right) = (2500\ cfm)\left(\frac{14.7}{40}\right)\left(\frac{280+460}{70+460}\right) = 1282.78\ Cfm$$

Note: At standard condition: t_1 = 70 °F and p_1 = 14.7 psi

Answer: b) 1283 cfm

10. Flue gas at a certain plant flows through a duct of cross section 3 ft^2 at a temperature of 350 °F at a rate of 35 000 lb/hr. It has the following compositions: N_2 = 75 %, O_2 = 2 %, CO_2 = 15 % and H_2O = 8 %, all by volume. The gas pressure is approximately equal to atmospheric. Determine the molecular mass of the gas.

a) 28.69 lb/pmol **b) 29.68 lb/pmol** c) 28.96 lb/pmol d) 29.86 lb/pmol

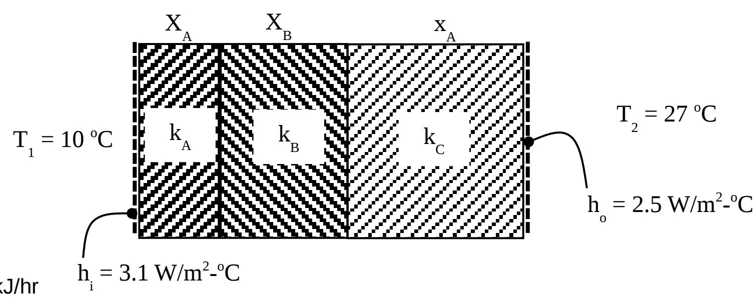
Solution:

$$MW = \sum (MW_i \cdot y_i) = 28N_2 + 32O_2 + 44CO_2 + 18H_2O = (28)(0.75) + (32)(0.02) + (44)(0.15) + (18)(0.08) = 29.68\ l$$

Answer: b) 29.68 lb/pmol

11. A wall is made up of an external thickness of brickwork 110 mm thick inside which is a layer of fiberglass 75 mm thick. The fiberglass is faced internally by an insulating board 25 mm thick. The coefficient of thermal conductivity for the three are as follows: brickwork, 1.5 W/m-K; fiberglass, 0.04 W/m-K; insulating board, 0.06 W/m-K. The surface transfer coefficient of the inside wall is 3.1 W/m^2-K while that of the outside wall is 2.5 W/m^2-K. Take the internal ambient temperature as 10 °C and the external temperature is 27 °C. Determine the heat loss through such wall 6 m and 10 m long.
a) 1189.3 W **b) 1189.3 kJ/hr** c) 1189.3 kW d) 330.36 kJ/min

Solution: $$q_k = \frac{A(\Delta T)}{\frac{1}{h_i} + \frac{x_A}{k_A} + \frac{x_B}{k_B} + \frac{x_C}{k_C} + \frac{1}{h_o}} = \frac{(10)(6)(27 - 10)}{\frac{1}{3.1} + \frac{0.025}{0.06} + \frac{0.075}{0.040} + \frac{0.110}{1.5} + \frac{1}{2.5}} = 330.36\ W = 1189.3\ kJ/Hr$$



Answer: b) 1189.3 kJ/hr

12. A Rankine cycle operates with a thermal efficiency of 35 % and the factor of evaporation of the boiler is 1.15. Determine the mass flow rate of steam if the cycle power output is 5.5 MW.
a) 6.05 kg/s b) 5.05 kg/s c) 4.05 kg/s d) 7.05 kg/s

Answers: a) 6.05 kg/s

Solution: $$Q_A = \frac{W_{net}}{e_{th}} = \frac{5500}{0.35} = 15714.3\ kW \qquad m_s = \frac{Q_A}{h_1 - h_B} = \frac{Q_A}{2257(FE)} = \frac{15714.3}{2257(1.15)} = 6.05\ kg/s$$

13. Flue gas at a certain plant flows through a duct of cross section 3 ft^2 at a temperature of 350 °F at a rate of 35 000 lb/hr. It has the following compositions: N_2 = 75 %, O_2 = 2 %, CO_2 = 15 % and H_2O = 8 %, all by volume. The gas pressure is approximately equal to atmospheric. Estimate the gas density.

a) 0.0502 lb/ft³ b) 0.0205 lb/ft³ c) 0.502 lb/ft³ d) 0.205 lb/ft³

Answer: a) 0.0502 lb/ft³

Solution:

$$MW = \sum (MW_i \cdot y_i) = 28N_2 + 32O_2 + 44CO_2 + 18H_2O = (28)(0.75) + (32)(0.02) + (44)(0.15) + (18)(0.08) = 29.68\ lb/p$$

$$\rho_g = \frac{p}{RT} = \frac{p}{\left(\frac{\bar{R}}{MW}\right)T} = \frac{14.7(144)\ lb/ft^2}{\left(\frac{1545.32}{29.68}\ Ft \cdot lb/lb\ ^oR\right)((350 + 460\ ^oR))} = 0.0502\ lb/ft^3$$

Note: Universal gas Constant, $\bar{R} = 1545.32 \frac{Ft \cdot lb}{pmol\ ^oR} = 8.3143 \frac{kJ}{kgmol\ ^oK}$

14. What is the specific gravity of a fuel at 26° Baume?
a) 0.9874 0.8794 **c) 0.8974** d) 0.9748

Solution: $$SG\,@15.6\ ^{o}C = \frac{140}{^{o}\,Baume + 130} = \frac{140}{26 + 130} = 0.8974$$

Answer: c) 0.8974

15. Flue gas at a certain plant flows through a duct of cross section 3 ft^2 at a temperature of 350 ^{o}F at a rate of 35 000 lb/hr. It has the following compositions: N_2 = 75 %, O_2 = 2 %, CO_2 = 15 % and H_2O = 8 %, all by volume. The gas pressure is approximately equal to atmospheric. Determine the gas velocity.

a) 3783.4 fpm b) 3837.4 fpm **c) 3873.4 fpm** d) 3387.4 fpm

Solution:

$$MW = \sum (MW_i \cdot y_i) = 28N_2 + 32O_2 + 44CO_2 + 18H_2O = (28)(0.75) + (32)(0.02) + (44)(0.15) + (18)(0.08) = 29.68\ lb/p$$

$$\rho_g = \frac{p}{RT} = \frac{p}{\left(\frac{\bar{R}}{MW}\right)T} = \frac{14.7(144)\ lb/ft^2}{\left(\frac{1545.32}{29.68}\ Ft \cdot lb/lb\ ^{o}R\right)\left((350 + 460\ ^{o}R)\right)} = 0.0502\ lb/ft^3$$

From continuity equation, $$V = \frac{m}{\rho A} = \frac{35000\ lb/hr}{(0.0502\ lb/ft^3)(3\ ft^3)} = 232\,403.72\ ft/hr = 3873.4\ fpm$$

Answer: c) 3873.4 fpm

16. At standard conditions, p = 14.7 psia and t = 32 ^{o}F, what is the volume of any per pmol?
a) 359 ft^3/pmol b) 539 ft^3/pmol c) 395 ft^3/pmol d) 593 ft^3/pmol

Note: For any gas, at 14.7 psia (101.325 kPaa) and 32 ^{o}F (0 ^{o}C): v = 359 ft^3/pmol = 22.43 m^3/kgmol

Answer: a) 359 ft^3/pmol

17. What is the percentage of the carbon content for one kg of benzene (C_6H_6)?
a) 92.3 % b) 85.2 % c) 93.2 % d) 82.5 %

Solution: $$MW = 12(6) + 1(6) = 72 + 6 = 78\ kg/kgmol$$ $$C = \left(\frac{72}{78}\right)(100\ \%) = 92.3\ \%$$

Answer: a) 92.3 %

18. Determine the heat flow rate across a 5 m^2 surface area of the brick wall with a thickness of 25 cm. It is maintained at 20 ^{o}C at one surface and 10 ^{o}C at the other surface. Thermal conductivity of the brick is 0.96 W/m-^{o}C.

a) 219 W **b) 192 W** c) 129 W d) 291 W

Solution: $$q_k = \left(\frac{k}{x}\right)A(\Delta T) = \left(\frac{0.96\ W/m\ ^{o}C}{0.25\ m}\right)(5\ m^2)(20 - 10\ ^{o}C) = 192\ W$$

Answer: b) 192 W

19. Indicator test that shows that the area of card is 33 mm^2, length of card is 50 mm. If spring scale is 1.72 MPa per mm, determine the MEP:
a) 1.781 Mpa b) 33 Mpa **c) 1.135 Mpa** d) 50 Mpa

Solution: Height of the Indicator card, $$h = \frac{33\ mm^2}{50\ mm} = 0.66\ mm$$

Mean Effective Pressure, $$MEP = (1.72\ MPa/mm)(0.66\ mm) = 1.135\ MPa$$

Answer: c) 1.135 MPa

20. Find the heat transferred to the engine per kW-hr if the thermal efficiency of a certain engine is 33%.

a) 10,909 kJ/kW-Hr b) 10,809 kJ/kW-hr c) 11,009 kJ/kw-Hr d) 11,119 kJ/kW-hr

Solution: $$HR = \frac{3600}{e_{th}} = \frac{3600}{0.33} = 10\,909.1\ kJ/kW \cdot hr$$

Answer: a) 10.909 kJ/kW-Hr

21. The thermal efficiency of a certain engine is 33%. Find the ratio of heat received to heat rejected.

a) 1.493 b) 1.593 c) 1.393 d) 1.293

Solution: $Q_A = W + Q_R \quad \rightarrow \quad 1 = \frac{W}{Q_A} + \frac{Q_R}{Q_A} = e_{th} + \frac{Q_R}{Q_A} \quad \frac{Q_A}{Q_R} = \frac{1}{1 - e_{th}} = \frac{1}{1 - 0.33} = 1.493$

Answer: a) 1.493

22. In an ideal Otto cycle, initial conditions are 101.3 kPa and 20°C. The cycle has a compression ratio of 6:1. Find the pressure temperature at the end of adiabatic compression.

a) 1244.5 kPa, 599.96 K b) 1244.5 kPa, 60 K c) 1244.5 kPa, gage 60 °C d) 1244.5 kPa, 599.96 °C

Answer: a) 1244.5 kPa, 599.96 K

Solution: $T_2 = T_1 (r_k)^{k-1} = (20 + 273)(6)^{0.4} = 599.97\ ^oK \qquad p_2 = p_1 (r_k)^k = 101.3 (6)^{1.4} = 1244.6\ kPaa$

23. The heat generated by fuel in a thermal power plant is 13,000kW. The plant generates 5 MW and has also 300 kW power needed for auxiliaries. What is the net thermal efficiency in%?

a) 26.15 % **b) 36.15 %** c) 31.56 % d) 38.55 %

Solution: $e_{th} = \left(\frac{5000 - 300}{13000} \right) (100\ \%) = 36.15\ \%$

Answer: b) 36.15 %

24. What is the final volume of the isentropic compression of 1 m^3 air from 20 kPaa to a pressure of 100 kPaa?

a) 1.9047 m^3 b) 0.5253 m^3 **c) 0.3168 m^3** d) 0.1061 m^3

Solution: $V_2 = V_1 \left(\frac{p_1}{p_2} \right)^{\frac{1}{k}} = (1\ m^3) \left(\frac{20}{100} \right)^{\frac{1}{1.4}} = 0.3168\ m^3$

Answer: c) 0.3168 m^3

25. A hydro-electric plant discharges water at the rate of 0.75 cubic meter per second and enters the turbine at 0.35 mps with a pressure of 275 KPa. Runner inside diameter is 550 mm, speed is 520 rpm and the turbine efficiency is 88%. Find the turbine speed factor.

a. 0.683 b. 0.386 **c. 0.638** d. 0.836

Solution: $V = \Phi \sqrt{2 g H_{eff}} = \pi D \left(\frac{n}{60} \right) \qquad \Phi = \frac{\pi D n}{60 \sqrt{2 g H_{eff}}} = \frac{\pi (0.55)(520)}{60 \sqrt{2 (9.8066)(28.04)}} = 0.638$

Answer: c) 0.638

26. Calculate the total time required to fill a spherical tank 3 meters in diameter using a pump that discharges 280 kg/min of water whose specific weight is 920 kg/m^3 (g = 9.765 m/s^2).

a) 46.5 minutes b) 45.6 minutes c) 54.5 minutes d) 46.5 minutes

Solution: Volume flow rate: $V = \frac{m}{\rho} = \frac{280\ kg/min}{930\ kg/m^3} = 0.3043\ m^3/min$ Tank Volume:

$$V_T = \left(\frac{4}{3} \right) \pi R^3 = \left(\frac{4}{3} \right) \pi (3)^3 = 14.14\ m^3$$

Time to fill the tank: $t = \frac{V_T}{V} = \frac{14.14}{0.3043} = 46.46\ min$

Answer: a) 46.5 minutes

27. An ideal gas at a pressure of 4120 kPaa and a temperature of 25 °C is contained in a cylinder with a volume of 20 m^3. A certain amount of the gas is released so that the pressure in the cylinder drops to 1730 kPaa. Expansion of the gas is isentropic. The heat capacity ratio is 1.4 and the gas constant is 0.286 kJ/kg-°C. Determine the mass of gas remaining in the cylinder, in kg.

a) 520.2 b) 522.0 c) 502.2 d) 250.2

Solution: $P_1 = 4120 \text{ kPaa}$ $P_2 = 1730 \text{ kpaa}$ $m_2 = ?$

$T_1 = 25 + 273 = 298\ ^oK$ $k = 1.4$

$V_1 = 20\ m^3$ $R = 0.286 \frac{ks}{kg\ ^oC}$

Discharging of tank:

$$\frac{m_2}{m_1} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{K}} = \frac{V_1}{V_2}$$

$$m_1 = \frac{P_1V_1}{RT_1} = \frac{4120(20)}{0.286(298)} = 966.82 \text{ kg}$$

$$m_2 = m_1\left(\frac{P_2}{P_1}\right)^{\frac{1}{K}} = 966.82\left(\frac{1730}{4120}\right)^{\frac{1}{1.4}} = 520.2 \text{ kg}$$

Discharging of tank:

$$T_2 = \left(\frac{C_P}{C_U}\right)T_L = K\ T_L$$

Answer: a) 520.2

28. A parallel flow air preheater receives air at 25 ºC and leaves at 110 ºC. The hot gas leaves at 130 ºC. Find the temperature of the hot gas entering when the LMTD is 67.4 ºC.

a) 185.27 ºC b) 150 ºC c) 158.72 ºC d) 172.58 ºC

Solution: $\theta_A = t_3 - 25$ $\theta_B = 130 - 110 = 20\ ^oC$

$$167.4 = \frac{\theta_A - 20}{\ln\left(\frac{\theta_A}{20}\right)}$$

$67.4(\ln \theta_A) - 67.4(\ln 20) = \theta_A - 20$ $67.4 (\ln \theta_A) - \theta_A = 181.91$

By trial and error and interpolation, $\theta_A = 160.27\ ^oC$ Then, $t_A = \theta_A + 25 = 160.27 + 25 = 185.27\ ^oC$

Answer: a) 185.27 ºC

29. The normal boiling point of liquid oxygen is 90°K. What is the temperature in °R?

a. 168.6 b. 194.6 **c. 162.6** d. 130.6

Solution: $T_R = t_f + 460 = \left(\frac{9}{5}t_c + 32\right) + 460 = \left(\frac{5}{9}(90 - 273) + 32\right) + 460 = 162.6\ ^oK$

Answer: c) 162.6 ºR

30. Refrigerant flows through a heat exchanger at a rate of 4.54 kg/min. Enthalpy of refrigerant entry is 237.24 kJ/kg and of refrigerant exit is 60.47 kJ/kg. Water coolant is allowed to rise 5.56°C. Determine the water flow rate in kg/min.

a. 0.70 **b. 34.5** c. 37.6 d. 50.8

Solution: $m_w = \frac{m_F(h_i - h_o)}{c_p(\Delta t)} = \frac{4.54(237.24 - 60.47)}{(4.187)(5.56)} = 34.47 \text{ kg/min}$

31. 142 liters per minute of fluid passes a boundary to a system. Calculate the pressure at this point if the flow energy of the fluid is 108.5 kJ/min.

a. 764 kPaa b. 987 kPaa c. 654 kPaa d. 345 kPaa

Solution: $p = \frac{E_f}{V} = \frac{108.5}{0.142} = 764.08 \text{ kPa}$

Answer: a) 764 kPaa

32. In an isometric process, 4 kg of a gaseous substance has 300 kJ of heat and undergoes a temperature change of 80 ºK. Determine the average specific heat in kJ/kg-ºK.

a. 0.6754 b. 0.1324 **c. 0.9375** d. 0.6754

Solution: $c_v = \frac{\Delta U}{m(\Delta T)} = \frac{300}{4(80)} = 0.9375\ kJ/kg \cdot {}^oK$

Answer: c) 0.9375

33. From feed water at 80 ºC (h_f = 334.9 kJ/kg), steam at a pressure of 0.90 MPaa (h_f = 743 kJ/kg, h_{fg} = 2031 kJ/kg) is generated in an exhaust gas boiler. If the dryness factor of the steam is 0.95, determine the heat transfer per kg steam.

a) 3237.55 kJ/kg **b) 2337.55 kJ/kg** c) 2733.55 kJ/kg d) 2755.33 kJ/kg

Solution: $h_2 = h_{f2} + x_2 h_{fg2} = 743 + (0.96)(2031) = 2672.45\ kJ/kg$

$q = \Delta h = h_2 - h_1 = 2672.45 - 334.9 = 2337.55\ \ kJ/kg$

Answer: b) 2337.55 kJ/kg

34. Atmospheric air (14.7 psi) at zero Fahrenheit temperature are compressed from 100 ft³ to a volume of 1 ft³ and temperature of 200 ºF, what will be the pressure of the compressed air in psia?

a) 2019.13 psia b) 2091.13 psia c) 2130.19 psia **d) 2109.13 psia**

Solution: $mR = \frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$ $p_2 = p_1\left(\frac{T_2}{T_1}\right)\left(\frac{V_1}{V_2}\right) = 14.7\left(\frac{660}{460}\right)\left(\frac{100}{1}\right) = 2109.13\ psia$

Answer: d) 2109..13 psia

35. A liquid, having a density of 1200 kg/m³, with a mass of 1kg is mixed with a 2 kg of another liquid having a density of 2000 kg/m³. If the volume of the mixture is the sum of the initial volumes, determine the de4nsity of the mixture.

a) 1636.4 kg/m³ b) 1664.3 kg/m³ c) 1463.6 kg/m³ d) 1364.6 kg/m³

Solution: $\rho = \frac{m_T}{V_T} = \frac{m_1 + m_1}{V_1 + V_2} = \frac{m_1 + m_2}{\frac{m_1}{\rho_1} + \frac{m_2}{\rho_2}} = \frac{1+2}{\frac{1}{1200} + \frac{2}{2000}} = 1636.36\ kg/m^3$

Answer: a) 1636.4 kg/m³

36. Find the mass of the fluid in a completely-filled 600 mm spherical drum. Density of the fluid is 640 kg/m³

a) 73.22 kg **b) 72.32 kg** c) 37.22 kg d) 27.32 kg

Answer: b) 72.32 kg

Solution:

$V_T = \frac{4}{3}\pi R^3 = \left(\frac{4}{3}\right)\pi(0.30)^3 = 0.113\ m^3$ $m = \rho V = 640(0.113) = 72.32\ kg$

37. What is the specific weight in N/m³ of the gas if its density is 0.003 slugs per cubic foot?

a) 12.5 b) 21.5 **c) 15.2** d) 25.1

Answer: c) 15.2

Solution: $\rho = (0.003\ slugs/ft^3)\left(\frac{32.2\ lb_m}{slug}\right)\left(\frac{3.28\ ft}{1\ m}\right)^3\left(\frac{1\ kg}{2.205\ lb}\right) = 1.546\ kg/m^3$

$$\gamma = \frac{\rho g}{k} = \frac{(1.546\ kg/m^3)(9.8066\ N/kg_f)}{9.8066\ \frac{kg \cdot m}{s^2 \cdot kg_f}} = 15.16\ N/m^3$$

38. Determine the hydrostatic pressure at the bottom of an oil storage tank which contains oil with a specific gravity of 0.88 and a depth of 20 m.

a) 1.67 kg_f/cm^2 | **b) 1.76 kg_f/cm^2** | c) 16.7 kg_f/cm^2 | d) 17.6 kg_f/cm^2

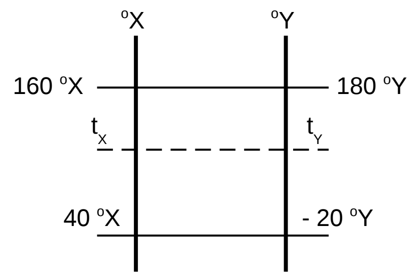
Answer: b) 1.76 kg/cm^2

Solution: $$p = \frac{\rho g h}{k} = \frac{(880\ kg/m^3)(9.8066\ m/s^2)(30\ m)}{1\ \frac{kg \cdot m}{s^2 \cdot N}} = 172\ 596.16\ N/m^3$$

$$p = (172596.16\ N/m^3)\left(\frac{1\ kg_f}{9.8066\ N}\right)\left(\frac{1m}{100\ cm}\right)^2 = 1.76\ kg_f/cm^2$$

39. On a hypothetical temperature scale X, the ice point is assigned the reading at 40° and the steam point at 160°. For another scale Y, the assigned values for ice point and steam point are – 20° and 180°, respectively. Convert a reading of 20 °X to the Y scale.
a) – 53.33 °Y | b) 35.33 °Y | c) 33.35 °Y | d) 35.45 °Y

Answer: a) – 53.33 °Y



Solution: $$\frac{160 - t_X}{160 - 40} = \frac{180 - t_Y}{180 + 20} \rightarrow \frac{160 - t_X}{120} = \frac{180 - t_Y}{200}$$

$$180 - t_Y = \left(\frac{200}{120}\right)(160 - t_X) = \left(\frac{5}{3}\right)(160 - t_x)$$

$$180(3) - 3t_y = 5(160) - 5t_x \qquad 540 - 3t_y = 800 - 5t_x$$

$$t_y = \frac{5t_x - 260}{3} = \frac{5(20) - 260}{3} = -53.33\ ^oY$$

40. What is the kinetic energy, in kJ/kg, of a high velocity flow of gas at 240 m/s?
a) 28.8 kJ/kg | b) 26.6 kJ/kg | c) 38.6 kJ/kg | d) 18.8 kJ/kg

Answer: a) 28.8 kJ/kg

Solution: $$ke = \frac{V^2}{2000} = \frac{(240\ m/s)^2}{2000} = 28.8\ kJ/kg$$

41. An engine receives 70 lbs of steam per minute with an enthalpy of 1600 Btu/lb and a velocity of 100 fps. It leaves the engine at 900 fps and 1320 Btu/lb enthalpy. Radiation loss is 84 000 Btu/hr. Which of the following is more appropriate to identify the type this engine?
a) Power engine | b) Carnot engine | **c) Reversed engine** | d) Brayton engine

Answer: c) Reversed engine

Solution: Q = ΔH + ΔPE + ΔKE + W

Where, ΔPE = 0 and m = m_1 = m_2 = 70 lb/min = 1.167 lb/s

Where, Q = - 84 000 Btu/hr = - 23.33 Btu/s = - 1400 Btu/min

ΔH = m (h_2 – h_1) = 1.167(1320 – 1600) = - 326.76 Btu/s = - 19 605.6 Btu/min

$$\Delta KE = \left(\frac{m}{2}\right)(V_2^2 - V_1^2) = \frac{\left(\frac{1.167}{2}\right)\left[(900)^2 - (100)^2\right]}{778} = 600\ Btu/s = 36000\ Btu/min$$

$$W = Q - \Delta H - \Delta KE = -1400 + 19605.6 - 36\ 000 = (-17794.4)\left(\frac{778}{33\ 000}\right) = -420\ Hp$$

Note: Since W is negative, it is a reversed engine.

42. In a turbine, steam flows at the rate of 10 kg/s and 10 kW of heat are lost from the turbine. Ignoring elevation and kinetic energy effects, calculate power output from the turbine. The enthalpy at the turbine inlet is 3140 kJ/kg and at the outlet is 3100 kJ/kg.

a) 390 kW b) 309 kW c) 903 kW d) 930 kW

Answer: a) 390 kW

Solution: Q = ΔH + ΔPE + ΔKE + W Where, ΔPE = 0 and ΔKE = 0

$$W = Q - \Delta H = Q - m(h_2 - h_1) = -10 - (10)(3100 - 3140) = 390\text{ kW}$$

43. 600 kg/hr of 40 °C feed water enters a steady flow system boiler to produce steam. Find the rate at which heat is transformed in kCal/hr if steam enthalpy is 660 kCal/kg.

a) 363 000 kcal/hr **b) 336 000 kcal/hr** c) 633 000 kcal/hr d) 306 300 kcal/hr

Answer: b) 336 000 kCal/hr

Solution: Q = ΔH + ΔPE + ΔKE + W Where, ΔPE = 0 and ΔKE = 0

$$Q = m(h_2 - h_1) = \left(\frac{6000}{60}\right)[600(4.187) - 40(4.187)] = 390.79\text{ kW} = 336\ 000\text{ kCal/hr}$$

44. In a gas turbine, 0.10 kg/s of hot gas at a temperature of 285 °C enters the nozzle at an enthalpy of 3100 kJ/kg and exits the nozzle at 3070 kJ/kg at a pressure of 5 MPaa. The gas has an approximate molecular weight of 28 and its specific heat ratio is 1.35. If the nozzle is considered to be well insulated, determine the exit gas velocity if the approach velocity is neglected.

a) 244.95 m/s b) 424.95 m/s c) 442.95 m/s d) 294.45 m/s

Answer: a) 244.95 m/s

Solution: Q = ΔH + ΔPE + ΔKE + WWhere Q = 0, W = 0, V_1 = 0, and ΔPE = 0 $\Delta KE = -\Delta H \rightarrow \frac{m(V_2^2 - V_1^2)}{2000} = -m(h_2 - h_1)$

$$V_2 = \sqrt{2000(h_1 - h_2)} = \sqrt{2000(3100 - 3070)} = 244.95\text{ m/s}$$

45. Determine the energy required by a 1/3-Hp pump if it operates for 20 minutes.

a) 298.4 b) 248.9 c) 289.4 d) 284.9

Answer: a) 298.4 kJ

Solution: $\text{Energy} = \frac{1}{3}\text{Hp}(0.746\text{ kW/Hp})(20)(60) = 298.4\text{ kJ}$

46. A 1-kg hammer moving with a velocity of 50 m/s strikes a 200-gram iron stake, driving it into the ground. If half of the energy goes into the iron rod, what will be its rise in temperature? C_p for iron = 0.14 kCal/kg-°K.

a) 5.33 °R **b) 5.33 K** c) 5.33 °F d) 3.53 °K

Answer: b) 5.33 K

Solution: $\Delta KE = \frac{mV_2^2}{2000} = \frac{(1)(50)^2}{2000} = 1.25\text{ kJ}$ $\frac{\Delta KE}{2} = mc_p(\Delta T)$

$$\Delta T = \frac{\Delta KE}{2mc_p} = \frac{1.25}{2(0.20)(0.14)(4.187)} = 5.33\ ^oK$$

47. Mechanical energy in the form of torque, 4000 N-m, is applied to an AC generator at a speed of 30 revolutions per second. The machine losses some of the energy in the form of heat losses at 44.44 kW and the remainder is transformed to the electrical form. Calculate the power produced, in kW.

a) 709.54 b) 790.54 c) 705.94 d) 750.49

Answer: a) 709.54

Solution: $W = \frac{\pi n T}{30} - Q = \frac{\pi(30)(60)(4)}{30} - 44.44 = 709.54\text{ kW}$

48. A 30 m power dam has a normal flow of 120 m³/s. Hydraulic turbines that can convert 94 % of the waterpower to the shaft power, are installed. The turbines are connected to the electric generators with an efficiency of 98.5 %. What is the kW capacity of the plant?

a) 35 303.76 | **b) 32 687.75** | c) 36 287.75 | d) 37 682.75

Answer: b) 32 687.75 kW

Solution: $WP = \frac{\rho g V(H)}{1000} = \frac{(1000)(9.8066)(120)(30)}{1000} = 35303.76 \text{ kW}$

$W_k = (0.94)(0.985)(35\ 303.76) = 32\ 687.75 \text{ kW}$

49. A 65 kg-m/s of work is converted by an electric motor from 1 kW of electrical input. If the speed is 1750 rpm, find the driven torque in N-m.

a) 4.38 | b) 8.34 | c) 4.83 | **d) 3.48**

Solution: $W = \frac{\rho g Q(H)}{1000} = \frac{1000(9.8066)(120)(30)}{1000} = 35303.76 \text{ kW}$

$P = \frac{\pi n T}{30} = W \qquad T = \frac{30W}{\pi n} = \frac{30(637.429)}{\pi(1750)} = 3.48 \text{ N.m}$

50. It is required to produce a steady output of 50 MW from a hydraulic turbine. It receives water from a reservoir at an elevation of 100 m above it. Calculate the minimum water flow in kg/s to produce this output.

a) 51 000 | b) 15 000 | c) 50 100 | d) 50 010

Answer: a) 51 000 kg/s

Solution: $WP = \frac{\rho g Q H}{1000} = \frac{MgH}{1000} \qquad m = \frac{1000 WP}{gH} = \frac{1000(50000)}{9.8066(100)} = 50986.1 \text{ kg/s}$

51. A 6m-diameter spherical balloon filled with gas weighing 5.5 N/m^3. In Standard air weighing 12 N/m^3, what is the maximum load including its weight that the balloon can lift?

a) 735.13 N | b) 753.31 N | c) 713.53 N | d) 751.33 N

Answer: a) 735.13 N

Solution: $F_g = W_a - W_B \qquad V_T = \frac{\pi}{6} d^3 = \frac{\pi}{6}(6)^3 = 113.097 \text{ m}^3 \qquad F_g = (12 - 5.5)(113.097) = 735.13 \text{ N}$

52. 0.5 kg of an ideal gas in a non-flow, closed, system has increased its temperature by 10 ºC while the gas does 10 kJ of work. What is the heat transfer, in kJ, if c_v = 0.9 kJ/kg-K?

a) 14.5 kJ | b) 15.4 kJ | c) 41.5 kJ | d) 51.4 kJ

Answer: a) 14.5 kJ

Solution: $Q = \Delta u + W \qquad Q = mc_v(T_2 - T_1) + W = 0.5(0.9)(10) + 10 = 14.5 \text{ kJ}$

53. 55,000 gallons of water passes through a heat exchanger and absorbs 29540000 kJ. The exit temperature is 45 ºC. Calculate the water entrance temperature.

a) 10.18 ºC | b) 18.01 ºC | c) 8.011 ºC | **d) 11.08 ºC**

Answer: d) 11.08 ºC

Solution: $V_T = (55000 \text{ gal})(3.4854 \text{ li/gal})\left[\frac{1 \text{ m}^3}{1000 \text{ li}}\right] = 208.197 \text{ m}^3$

$m = \rho V = 1000(208.197) = 208197 \text{ kg}$

$Q = mc_p(T_2 - T_1) \qquad T_1 = T_2 - \frac{Q}{mc_p} = (45 + 273) - \frac{29540000}{208197(4.187)}$

$T_1 = 284.113\ ^o\text{k} \qquad t_1 = 11.113\ ^o\text{C}$

54. Ammonia flows through a heat exchanger with a rate of 5kg/min. Water coolant is allowed to rise to 10 ºC. Enthalpy of ammonia at entry is 240 kJ/kg and at exit is 80 kJ/kg Determine the water flow rate, in kg/min.

a) 19.11 kg/min b) 11.19 kg/min c) 11.91 kg/min d) 91.11 kg/min

Answer: a) 19.11 kg/min

Solution: $m_w c_{pw}(\Delta t)_w = m_1(h_1 - h_2)$ $\qquad m_w = \frac{5(240-80)}{4.187(10)} = 19.11\ kg/min$

55. A power unit is burning 1 055 000 kJ/hr of fuel with high and low temperature extremes of 840 °C and 5 °C. Determine the maximum hp output of the unit.

a) 249.72 Hp b) 279.24 Hp c) 247.92 Hp **d) 294.72 Hp**

Answer: d) 294.72 Hp

Solution: $\frac{W}{Q_H} = \frac{T_H - T_L}{T_H}$ $\qquad W = Q_H\left(\frac{T_H - T_L}{T_H}\right) = \left(\frac{1055000}{3600}\right)\left(\frac{840-5}{840+273}\right)$ $W = 219.86\ kw = 294.715\ Hp$

56. An Otto engine operates on hot-air standard with k=1.35. The conditions at the beginning of compression are 101.325 kPaa, 0.05 m^3 and 32 °C. The clearance is 8 % and 15 kJ are added per cycle. Determine the mean effective pressure.

a) 193.7 kPa b) 173.9 kPa c) 139.7 kPa d) 179.3 kPa

Answer: a) 193.7 kPa

Solution: $r_k = \frac{c+1}{c} = \frac{1.08}{0.08} = 13.5$ $\qquad e_{th} = \left(1 - \frac{1}{(r_k)^{k-1}}\right)(100\ \%) = \left(1 - \frac{1}{(13.5)^{0.35}}\right)(100\ \%) = 59.785\ \%$

$$W = e_{th}(Q_H) = 0.59785(15) = 8.968\ kJ \qquad V_2 = \frac{V_1}{r_k} = \frac{0.05}{13.5} = 0.0037\ m^3$$

$$p_m = \frac{W}{V_D} = \frac{W}{V_1 - V_2} = \frac{8.968}{0.05 - 0.0037} = 193.69\ kPa$$

57. The cycle work of an air standard Otto engine is 1000 kJ/kg. What is the compression ratio of the engine if the maximum cycle temperature is 3173 °K and the temperature at the end of isentropic compression is 773 °K

a) 8.74 b) 7.84 c) 7.48 d) 8.47

Answer: a) 8.74

Solution: $e_{th} = \frac{W}{Q_A} = \frac{W}{c_v(T_3 - T_2)} = \left(\frac{1000}{0.7186(3173-773)}\right)(100\ \%) = 57.98\ \%$ $\qquad e_{th} = \left(1 - \frac{1}{(r_k)^{k-1}}\right)(100\ \%)$

$$r_k = \left(\frac{1}{1 - e_{th}}\right)^{\frac{1}{k-1}} = \left(\frac{1}{1 - 0.5798}\right)^{\frac{1}{0.4}} = 8.74$$

58. A heat exchanger receives hot gas at 150 °F and leaves at 90 °F. The cold water enters at 81 °F and leaves at 95 °F. Determine the AMTD .

a) 25.41 °F **b) 32 °F** c) 23 °F d) 24.51 °C

Answer: b) 32 °F

Solution: θ_A = 90 – 81 = 9 °F $\qquad \theta_B$ = 150 - 95 = 55 °F $\qquad AMTD = \frac{9+55}{2} = 32\ ^oF$

59. Determine the number of wells required for a 20 000 kW geothermal power plant which has a generator efficiency and turbine efficiency of 90 % and 80 %, respectively. The quality of steam after throttling is 23 % and each well is to discharges 250 000 kg/hr of water. The change of enthalpy at entrance and exit of the turbine is 600 kJ/kg.

a) 2 wells b) 4 wells **c) 3 wells** d) 1 well

Answer: c) 3 wells

Solution: $m_s = \frac{W_t}{\eta_g \eta_t (\Delta h)} = \frac{20000}{(0.90)(0.80)(600)} = 46.296 \text{ kg/s} = 166666.67 \text{ kg/hr}$

$$m_c = \frac{m_s}{x_3} = \frac{166\ 666.67}{0.23} = 724637.68 \text{ kg/hr} \qquad \text{No of Wells} = \frac{724637.68}{250000} = 2.89 \approx 3 \text{ Wells}$$

60. Determine the molecular mass of the gas which has the following percentage volumetric compositions: CH_4, 59.8 %; C_2H_6, 37.6 %; N_2, 2.2 %; and CO_2, 0.4 %.

a) 24.61 kg/kgmol **b) 21.64 kg/kgmol** c) 26.14 kg/kgmol d) 24.16 kg/kgmol

Answer: b) 21.64 kg/kgmol

Solution: Solving for the molecular mass or weight, MW = $16CH_4 + 30C_2H_6 + 28N_2 + 44CO_2$

MW = 16(0.598) + 30(0.376) + 28(0.022) + 44(0.004) = 21.64 kg/kgmol fuel

61. Determine the required volume flow rate of water in lps. for a 100 TR system to produce chilled water from 22 C to 2 C.

a) 3.2 lps **b) 4.2 lps** c) 3.8 lps d) 4.8 lps
Answer: b) 4.2 lps

Solution: Solving for the volume flow rate of chilled water, $m_{cw} = \frac{Q_e}{c_p(t_{cw1} - t_{cw2})}$

$$m_{cw} = \frac{100(3.516)}{4.187(22 - 2)} = 4.199 \text{ kg/s}$$

$$V_{cw} = 4.199 \text{ kg/s} (1 \text{ liter/kg} = 4.199 \text{ lps})$$

62. The volumetric efficiency of a refrigeration compressor is 90 %. It has a specific volume of 0.0482 m^3/kg at entrance and 0.017 m^3/kg at the exit. Determine the percent clearance of the compressor.

a) 5.45 % b) 5.54 % c) 4.55 d) 5.65 %

Answer: a) 5.45 %

Solution: Solving for the percent clearance, $\eta_v = \left[1 + c - c\left(\frac{p_2}{p_1}\right)^{\frac{1}{k}}\right](100\ \%) = \left[1 + c - c\left(\frac{V_1}{V_2}\right)\right](100\ \%)$

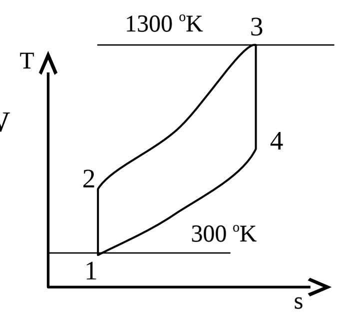
$$c = \frac{\eta_v - 1}{\left(1 - \frac{v_1}{vv_2}\right)}(100\ \%) = \left[\frac{0.60 - 1}{1 - \left(\frac{0.0482}{0.017}\right)}\right](100\ \%) = 5.45\ \%$$ ans.

63. In an ideal standard Brayton cycle, 1.5 kg/s of air at 101 kPaa and 27 °C is compressed isentropically to a certain pressure and temperature after which the is added until the temperature becomes 1027 °C. Isentropic expansion occurs in the turbine. Determine the net power produced by the cycle.
a) 629.56 kW b) 592.65 kW **c) 529.76 kW** d) 579.26 kW

Answer: c) 529.76 kW

Solution: $T_2 = T_4 = \sqrt{T_1 T_4} = \sqrt{(300)(1300)} = 624.5\ ^oK$

$$W_{net} = mc_p(T_3 - 2T_2 + T_1) = (1.5)(1.0062)|1300 - 2(624.5) + 300| = 529.76 \text{ kW}$$



64. What is the thermal efficiency of an air standard Otto cycle if the clearance volume is 12 % of the displacement volume?

a) 57 % **b) 59 %** c) 58 % d) 60 %

Answer: b) Thermal efficiency = 59 %

Solution:

$$V_2 = 0.12V_D \qquad r_k = \frac{V_1}{V_2} = \frac{V_2 + V_D}{V_2} = \frac{0.12V_D + V_D}{0.12V_D} = \frac{1.12}{0.12} = 9.33$$

$$e_{th} = \left(1 - \frac{1}{(r_k)^{k-1}}\right)(100\ \%) = \left(1 - \frac{1}{(9.33)^{0.4}}\right)(100\ \%) = 59.08\ \%$$

65. A certain coal has the following ultimate analysis by weight. C = 67 %, Ash = 5 %, Moisture = 8 %, N = 6 %, H = 3 %, Sulfur = 7 %, O = 4 %. Calculate the higher heating value in kCal/kg.

a) 6 453.51 b) 5 643.51 c) 4563.51 d) 3 653.51

Answer: a) 6 453.51 kCal/kg

Solution: $HHV = 14\,600\,C + 62\,000\left(H_2 - \frac{O_2}{8}\right) + 4\,050\,S = (14\,600)(0.67) + (62000)\left(0.03 - \frac{0.04}{8}\right) + (4050)(0.07)$

HHV = 11 615.5 Btu/lb = 27 020.85 kJ/kg = 6 453.51 kCal/kg

66. If an airplane is flying at an altitude of 1 800 m, what is the approximate atmospheric temperature at the said altitude if the temperature at the ground is 21 °C?

a) **9.3 °C** b) 10.3 °C c) 8.3 °C d) 7.3 °C

Solution: $p = 21\ ^oC - \left(\frac{6.5\ ^oC}{1000\ m}\right)(1800\ m) = 9.3\ ^oC$

Note: Barometric pressure reduces by 1 inch Hg per 1000 ft rise in elevation or 83.312 mm Hg per 1000 m rise in elevation.
Barometric temperature reduces by 3.566 °F per 1000 ft rise in elevation, or 6.5 °C per 1000 m rise in elevation.

67. Air at 1 MPaa and 310 °C is expanded to 250 kPaa in accordance with the relation $pV^{1.25} = C$. Determine the temperature after expansion in °F.

a) 335.9 °F b) 168.83 °F c) 441.83 °K d) 795.9 °R

Answer: a) Final temperature, t_2 = 335.9 °F

Solution: $T_2 = T_1\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} = (310 + 273)\left(\frac{250}{1000}\right)^{\frac{0.25}{1.25}} = 441.83\ ^oK$ t_2 = 168.83 °C = 335.9 °F

68. A Rankine cycle operates with a thermal efficiency of 40 % and the mass flow rate of steam is 5.3 kg/s. Determine the factor of evaporation if the cycle power output is 5.5 MW.

a) 1.15 b) 1.25 c) 1.5 d) 1.75

Answer: a) Factor of Evaporation, FE = 1.15

Solution: $Q_A = \frac{W_{net}}{e_{th}} = \frac{5500}{0.40} = 13\ 750\ kW \quad FE = \frac{Q_A}{2257\,m_s} = \frac{13\,750}{2257(5.3)} = 1.15$

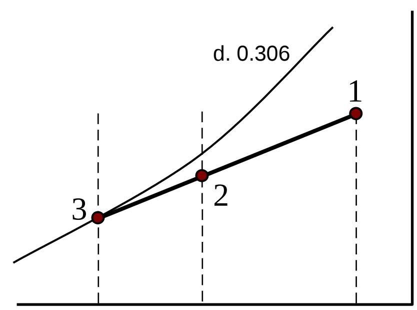
69. 28°C DB, 21 WB and 101.325 Kpaa humid air flows across a cooler coil at a rate of 2.5 m^3/s. It leaves at 12.5°C DB and 0.0083 kg vapor per kg dry air. If the apparatus dew point (ADP) is 8.5, compute for the contact factor (CF).

a) 0.835 **b. 0.795** c. 0.579 d. 0.306

Answer: b) 0.795

Solution:

$$CF = \frac{t_1 - t_2}{t_1 - t_3} = \frac{h_1 - h_2}{h_1 - h_3} = \frac{W_1 - W_2}{W_1 - W_3} = \frac{28 - 12.5}{28 - 8.5} = 0.795$$



70. In a reverse Carnot cycle, the minimum and maximum temperatures are – 25 C and 72 C, respectively. If the heat rejected at the condenser is 6000 kJ/min, find the tons of refrigeration required to operate the system.

a) 20.44 TR b) 24.40 TR c) 42.20 TR d) 44.20 TR

Answer: a) 20.44 TR

Solution: $TR = \frac{Q_L}{3.517} = \frac{\Delta S(T_L)}{3.517} = \frac{17.39(248)}{60(3.517)} = 20.44 \text{ tons}$

71. Determine the brake power input for the pump to draw water at a head of 110 m and a discharge rate of 550 lps. Pump efficiency is 70%.

a) 847.57 kW b) 874.57 kW c) 875.74 kW d) 854.75 kW

Answer: a) 847.57 TR

Solution: $BP = \frac{\rho g Q(TDH)}{1000\eta_p} = \frac{1000(9.8066)(0.55)(110)}{1000(0.70)} = 847.57 \text{ kW}$

72. Water leaves a cooling tower at a temperature of 27 °C. If the approach and efficiency of tower are 10 °C and 65 %, respectively, determine the temperature of water entering the tower.

a) 54.57 °C b) 55.47 °C **c) 45.57 °C** d) 54.75 °C

Answer: c) 45.57 °C

Solution: $WB_1 = t_4 - CA = 27 - 10 = 17\ ^oC$

$$e_t = \frac{ACR}{TCR} = \frac{t_3 - t_4}{t_3 - WB_1}$$

$$t_3 = \frac{t_4 - e(WB_1)}{1 - e} = \frac{27 - (0.65)(17)}{1 - 0.65} = 45.57\ ^oC$$

73. A refrigeration system operates on liquid ammonia as refrigerant. Ammonia at a temperature of 26 °C is available at the expansion valve. The temperature of the vaporizing ammonia in the evaporator is 2 °C. Find the percentage of liquid vaporized while flowing through the expansion valve. Properties of refrigerant: At t = 2 °C, h_f = 190.4 kJ/kg and h_g = 1445.6 kJ/kg; At 26 °C, h_f = 303.6 kJ/kg and h_g = 1465.6 kJ/kg.

a) 10.2 % **b) 9.02 %** c) 11.02 % d) 12.02 %

Answer: b) 9.02 %

Solution: $x_4 = \left[\frac{h_4 - h_{f4}}{h_{fg4}}\right](100\ \%) = \left[\frac{303.6 - 190.4}{1445.6 - 190.4}\right](100\ \%) = 9.02\ \%$

74. An engine uses 25 °API fuel with fuel consumption of 40 kg/hr. Determine the brake power of the said engine if it has a brake thermal efficiency of 35 %.

a) 160.67 kW **b) 173.52 kW** c) 174.52 kW d) 165.84 kW

Answer: b) 173.52 kW

Solution: $HHV = 41130 + 139.6(^o API) = 41130 + 139.6(25) = 44\,620 \text{ kJ/kg}$

$$BP = Q_F(e_B) = m_F(HHV)(e_B) = \left[\frac{40}{3600}\right](44\ 620)(0.35) = 173.52 \text{ kW}$$

75. The volumetric efficiency of a refrigeration compressor is 90%. It has a specific volume of 0.0482 m^3/kg at entrance and 0.017 m^3/kg at the exit. Determine percent clearance of the compressor.

a) 5.45 % b) 5.54 % c) 4.55 % d) 5.65 %

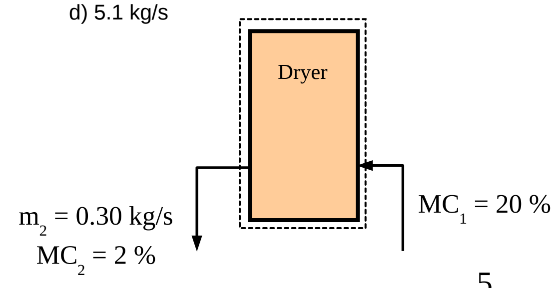
Answer: a) 5.45 %

Solution: $\eta_v = 1 + c - c\left[\frac{v_1}{v_2}\right]$ $c = \left[\frac{\eta_v - 1}{1 - \frac{v_1}{v_2}}\right](100\ \%) = \left[\frac{0.90 - 1}{1 - \frac{0.0482}{0.017}}\right](100\ \%) = 5.45\ \%$

76. Palay enters a dryer with 20% moisture and is to deliver with 2% moisture at 0.30 kg/s. Determine the mass of air required if the change in humidity ratio is 0.0165 kg/kg da.

a) 4.1 kg/s b) 2.1 kg/s c) 3.1 kg/s d) 5.1 kg/s

Answer: a) 4.1 kg/s

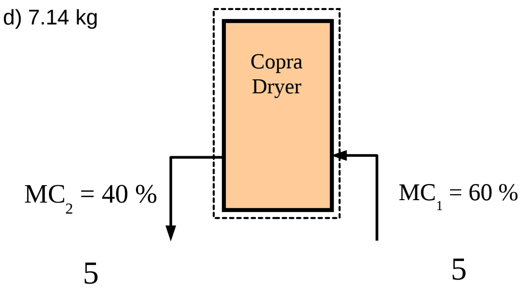


Solution: $m_1 = \dfrac{m_2(1 - MC_2)}{1 - MC_1} = \dfrac{0.30(1 - 0.02)}{1 - 0.20} = 0.3675\ kg/s$

$$m_a = \frac{m_1 - m_2}{\Delta W} = \frac{0.3675 - 0.30}{0.0165} = 4.091\ kg/s$$

77. A dryer is to deliver copra with 5 % water and 95 % solids. Copra contains 60 % water and 40 % of solids in the feed. Find the amount of water removed based on a 5 kg of bone-dry-material.

a) 3.17 kg **b) 4.17 kg** c) 1.47 kg d) 7.14 kg



Answer: b) 4.17 kg

Solution: $m_1 = \dfrac{BDM}{1 - MC_1} = \dfrac{5}{1 - 0.60} = 12.5\ kg$

$$m_2 = \frac{BDM}{1 - MC_2} = \frac{5}{1 - 0.40} = 8.33\ kg$$

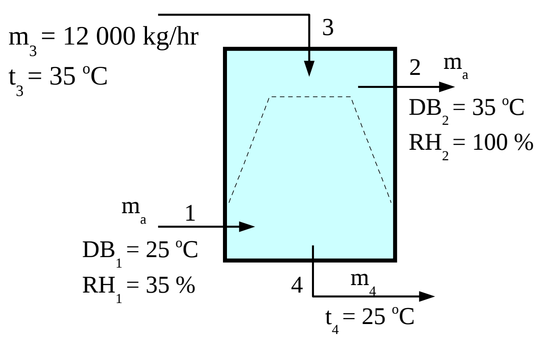
Mass of water removed: $m_w = m_1 - m_2 = 12.5 - 8.33 = 4.17\ kg$

78. In an industrial cold storage plant, a cooling tower cools 12 000 kg/min of water from 35 °C to 25 °C. The inlet air to the cooling tower has a temperature of 25 °C DB and 35 % RH (h = 42.65 kJ/kg d.a., W = 0.0069 kg/kg d.a., v = 0.75 m^3/kg). Air leaves the cooling tower saturated at 35 °C (h = 129.07 kJ/kg, W = 0.0366). Calculate the volume flow rate of air required by the cooling tower in m^3/min.

a) 4 360.45 m^3/min b) 3 460.45 m^3/min c) 5 460.35 kg/min d) 4 063.54 m^3/min

Answer: a) 4360.45 m^3/min

Solution:



- Neglecting losses such that heat absorbed by the cooling water from the condenser is equal to the heat rejected to the air.

$$q_w = q_a \quad \rightarrow \quad m_a(h_2 - h_1) = m_w c_p (t_3 - t_4)$$

Solving for the mass flow rate of air, $m_a = \dfrac{m_w c_p (t_3 - t_4)}{h_2 - h_1} = \dfrac{12\,000(4.187)(35 - 25)}{129.07 - 42.65} = 5813.93\ kg/min$

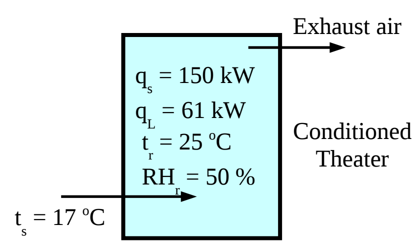
Solving for the volume flow rate of surrounding air, $Q_1 = m_a v_1$ = (5 813.93)(0.75) = 4 360.45 m^3/min.

79. An auditorium is to be maintained at 25 °C DB and 50 % RH (W_r = 0.0098 kg/kg d.a., p_{dr} = 3.169 kPaa). The supply air enters the theater at 17 °C. The sensible and latent heat loads are 150 kW and 61 kW, respectively. Determine the humidity ratio of the supply air.

a) 0.0085 b) 0.085 c) 0.0058 d) 0.058

Answer: a) 0.0085

Solution: Solving for m_s, $q_s = 1.0062\ m\ (t_r - t_s)$



$$m_s = \frac{q_s}{1.0062(t_r - t_s)} = \frac{150}{1.0062(25 - 17)} = 18.63 \text{ kg/s}$$

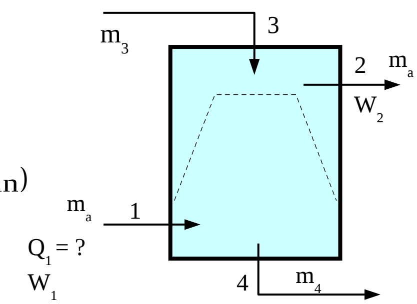
Solving for W_s, q_l = 2 501 m (W_r – W_s):

$$W_s = W_r - \frac{q_L}{2501 m_s} = 0.0098 - \frac{61}{2501(18.63)} = 0.0085 \text{ kg/kg da}$$

80. The change in humidity ratio in a cooling tower is 0.025 kg_{wv}/kg_{da}. The amount of water carried by air is 0.1134 kg/sec. Calculate the volume of air needed in a cooling tower if the specific volume is 0.0385 m^3/kg expressed in m^3/min.

a. 5.10 b. 7.85 **c. 10.5** d. 12.95

Answer: c) 10.5 m^3/min



Solution: $m_v = m_a(\Delta W)$ $\quad m_a = \frac{m_v}{\Delta W} = \frac{0.1134}{0.025} = 4.536 \text{ kg/s}$

$$Q_1 = m_a v_a = (4.536 \text{ kg/s})(0.0385 \text{ m}^3\text{/kg da})(60 \text{ sec/min})$$

$$= 10.48 \text{ m}^3\text{/min}$$

81. A lodge is to be maintained at 25 °C DB and 50 % RH. The supply air enters the lodge at 17 °C. The sensible and latent heat loads are 150 kW and 60 kW, respectively. Determine the sensible heat ratio.

a) 0.714 b) 0.814 c) 0.753 d) 0.853

Answer: a) 0.714

Solution: $SHR = \frac{q_s}{q_s + q_L} = \frac{150}{150 + 60} = 0.714$

82. A motel is to be maintained at 20 °C dry bulb, 52 % relative humidity. Sensible heat load is 500 000 kJ/hr while latent heat load is 20 000 kJ/hr. Determine the amount of air at 15 °C that must be supplied in kg/hr. Assume c_p of air is 1.0062 kg/kg-°K.

a) 100 383.82 kg/hr b) 98 393.82 kg/hr c) **99 383.82 kg/hr** d) 99 883.32 kg/hr

Answer: c) 99 383.82 kg/hr

Solution: $q_s = m_a c_p (t_r - t_s)$ $\quad m_a = \frac{q_s}{c_p(t_r - t_s)} = \frac{500\,000 \text{ kJ/hr}}{(1.0062 \text{ kJ/kg}\cdot{}^{o}\text{K})(20 - 15)} = 99\,383.82 \text{ kg/hr}$

83. Hot water from an engine enters the cooling tower circuit at 50°C and exits the tower at 32°C. If the ambient conditions is at 35°C dry bulb and 24°C wet bulb, what is the cooling effectiveness of the cooling tower in percent?

a. 59.23 b. 64.23 **c. 69.23** d. 74.23

Solution: $e = \frac{ACR}{TCR}(100\ \%) = \left[\frac{t_3 - t_4}{t_3 - WB_1}\right](100\ \%) = \left[\frac{50 - 32}{50 - 24}\right](100\ \%) = 69.23\ \%$

84. A moist air is at 30 °C dry bulb and specific humidity of 0.015 kg/kg dry air. Barometric pressure is 90 kPa. Determine the specific volume of the moist air.

a) 0.98 m^3/kg d.a. b) **0.99 m^3/kg d.a** c) 0.89 m^3/kg d.a d) 0.88 m^3/kg d.a

Answer: b) 0.99 m^3/kg d.a

Solution: $p_v = \frac{W(p_t)}{W + 0.622} = \frac{(0.015)(90)}{0.015 + 0.622} = 2.119 \text{ kPaa}$

$$v = \frac{RT}{p_t - p_v} = \frac{(0.28708)(30 + 273)}{90 - 2.119} = 0.9898 \text{ m}^3/\text{kg d.a.}$$

85. A glass window in a storefront has an area of 12 m^2 and a thickness of 1 cm. The thermal conductivity of the glass is 0.8 W/m-°C. On the cold day, outside surface temperature of the glass is – 1 °C and the inside surface temperature is 3 °C. Determine the heat transfer rate through the glass.

a) 3 840 W b) 4 830 W c) 3 084 W d) 4 083 W

Answer: a) 3840 W

Solution: Solving for the rate of heat transfer: $q_k = \left(\frac{kA}{L}\right)(T_1 - T_2) = \frac{(0.8 \text{ W/m}\cdot^o\text{C})(12 \text{ m}^2)}{0.01 \text{ m}}(3 + 1) = 3840 \text{ W}$

86. If a 2.5-kg metal rod with c_p = 1.5 kJ/kg-°K, at 150 °C is submerged to a 20-kg water at 20 °C, what is the equilibrium temperature of the rod and water?

a) 25.6 °C b) 52.6 °C c) 26.5 °C d) 62.5 °C

Answer: a) 25.6 °C

Solution: $m_r c_{pr}(T_r - T) = m_w c_{pw}(T - T_w)$

$$T = \frac{m_r c_{pr} T_r + m_w c_{pw} T_w}{m_w c_{pw} + m_r c_{pr}} = \frac{2.5(1.5)(150 + 273) + 20(4.187)(20 + 273)}{20(4.187) + 2.5(1.5)} = 298.57 \ ^o\text{K}$$

t = 25.57 °C

87. A concrete wall has a surface area of 500 m^2 and a thermal conductance of 0.7 W/m-K. The wall thickness is 20 cm. The outside wall temperature is 0 °C during the winter and the inside wall surface is 20 °C. Calculate the heat flux through the wall.

a) 50 W/m^2 b) 60 W/m^2 **c) 70 W/m^2** d) 80 W/m^2

Answer: c) 70 W/m^2

Solution: Solving for the heat flux through the wall: $\frac{q_k}{A} = \left(\frac{k}{x}\right)(\Delta T) = \left(\frac{0.70}{0.20}\right)(20 - 0) = 70 \text{ W/m}^2$

88. A kiln wall consists of a 1.2-cm-thick stainless steel inner layer covered by a 5-cm-thick outer layer of asbestos board insulation. The temperature of the inside surface of the stainless steel is 800 K and the outside surface of the asbestos is 350 K. Determine the temperature of the interface between the stainless steel and the asbestos. Conductance values: Stainless steel, k_A = 19 W/m-K; Asbestos, k_B = 0.7 W/m-°K.

a) 976.06 °K b) 679.06 °K **c) 796.06 °K** d) 769.06 °K

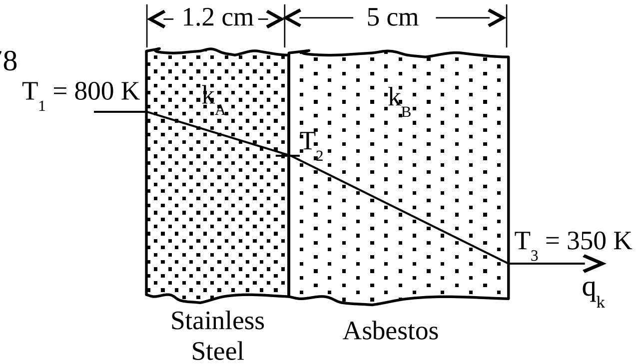
Answer: c) 796.06 K

Solution: Heat Flux, $\frac{q_k}{A} = \frac{\Delta T}{\left(\frac{x}{k}\right)_A + \left(\frac{x}{k}\right)_B} = \frac{800 - 350}{\left(\frac{0.012}{19}\right) + \left(\frac{0.05}{0.7}\right)} = 6\,244.78 \text{ W/m}^2$

Solving for the interface temperature:

$$\left(\frac{q_k}{A}\right) = \left(\frac{q_A}{A}\right) = \frac{T_1 - T_2}{\left(\frac{x}{k}\right)_A} = \frac{800 - T_2}{\left(\frac{0.012}{19}\right)} = 6\,244.78$$

T_2 = 796.06 °K



Other Solution: $\left(\frac{q_k}{A}\right)_A = \left(\frac{q_k}{A}\right)_B$ $\quad \frac{T_1 - T_2}{\left(\frac{x}{k}\right)_A} = \frac{T_2 - T_3}{\left(\frac{x}{k}\right)_B}$

$$\frac{800 - T_2}{\left(\frac{0.012}{19}\right)} = \frac{T_2 - 350}{\left(\frac{0.05}{0.7}\right)}$$ T_2 = 796.06 °K

Note: Temperature drop across the stainless steel is only 4 K while across asbestos is 446 K.

89. A pipe is located in a room where the ambient air temperature is 30 °C. It carries steam at 110 °C. The pipe (k = 185 W/m-K) has an internal diameter (ID) of 10 cm and an outside diameter (OD) of 12 cm. If the convective heat transfer coefficient between the pipe and air is 15 W/m^2-K. Determine the heat transfer rate per unit length of pipe if the pipe is un-insulated.

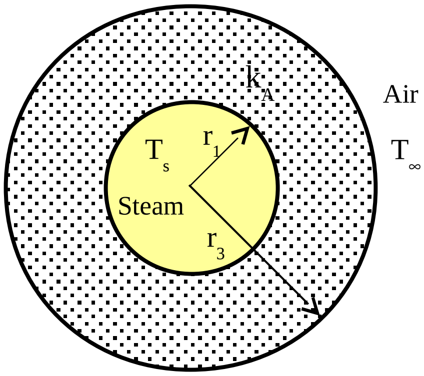
a) 452 W/m b) 542 W/m c) 254 W/m d) 245 W/m

Answer: a) 452 W/m

Solution: For the un-insulated pipe

- The only significant resistance to heat flow are the conductive resistance of the pipe and the convective resistance of the room air. Since convective resistance of steam is negligible.

$$\frac{q_k}{L} = \frac{2\pi(T_s - T_\infty)}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{k} + \frac{1}{r_2 h_o}} = \frac{2\pi(110 - 30)}{\frac{\ln\left(\frac{6}{5}\right)}{185} + \frac{1}{(0.06)(15)}} = 451.99 \text{ W/m}$$

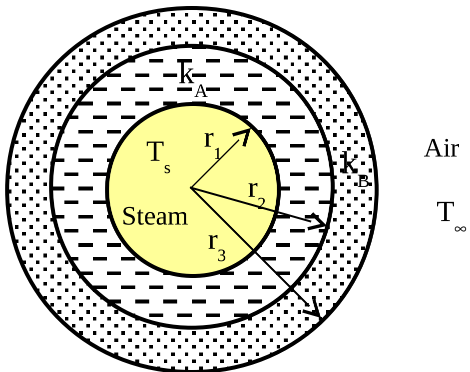


90. A pipe is located in a room where the ambient air temperature is 30 °C. It carries steam at 110 °C. The pipe (k = 185 W/m-K) has an internal diameter (ID) of 10 cm and an outside diameter (OD) of 12 cm. If the convective heat transfer coefficient between the pipe and air is 15 W/m^2-K. To reduce the heat loss from the pipe, it is covered with a 5-cm-thick layer of insulation (k = 0.20 W/m-K). Determine the heat transfer rate per unit length from the insulated pipe. Assume that convective resistance of the steam is negligible.

a) 138.3 W/m **b) 121.33 W/m** c) 165.8 W/m d) 168.5 W/m

Answer: b) 121.33 W/m

Solution:
$$\frac{Q_k}{L} = \frac{T_s - T_\infty}{\frac{\ln\left(r_2/r_1\right)}{2\pi k_A} + \frac{\ln\left(r_3/r_2\right)}{2\pi k_B} + \frac{1}{2\pi r_2 h_c}} = \frac{2\pi(110 - 30)}{\frac{\ln(6/5)}{(185)} + \frac{\ln(11/6)}{(0.2)} + \frac{1}{(0.06)(15)}} = 121.33 \text{ W/m}$$



91. A 1-mm-diameter electrical wire is covered with a 2-mm thick layer of insulation (k = 0.5 W/m-°K). The wire is surrounded by air with an ambient temperature of 25 °C and h_c = 10 W/m^2-°K. The wire temperature is 100 °C. Determine the Biot number.
a) 0.02 b) 0.03 **c) 0.05** d) 0.07

Answer: c) 0.05

Solution: $\text{Biot Number, } B_i = \frac{h_c r_o}{k_I} = \frac{10(2+0.5)10^{-3}}{0.5} = 0.05$

- Since $B_i < 1$, the presence of insulation will increase the heat transfer from the wire.

92. A 1-mm-diameter electrical wire is covered with a 2-mm thick layer of insulation (k = 0.5 W/m-°K). The wire is surrounded by air with an ambient temperature of 25 °C and h_c = 10 W/m^2-°K. The wire temperature is 100 °C. Determine the rate of heat dissipated from the wire per unit length. Assume that the wire temperature is not affected by presence of insulation.
a) 10.90 W/m b) 9.10 W/m c) 19.0 W/m d) 1.90 W/m

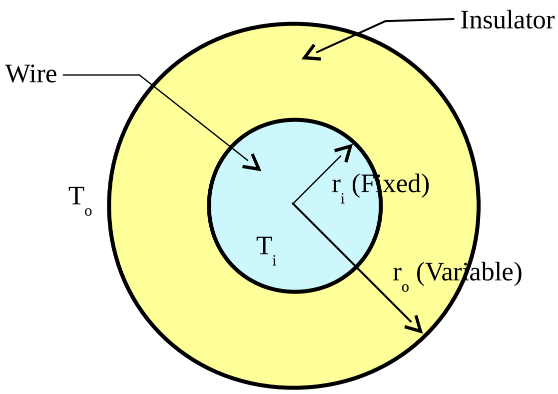
Answer: a) 10.90 W/m

Solution:

Solving for the Biot Number: $B_i = \frac{h_c r_o}{k_I} = \frac{10(2+0.5)10^{-3}}{0.5} = 0.05$

- Since $B_i < 1$, the presence of insulation will increase the heat transfer from the wire.

Consider the wire with Insulation: $\frac{q_k}{L} = \frac{T_i - T_\infty}{\frac{\ln\left(\frac{r_o}{r_i}\right)}{2\pi k_I} + \frac{1}{2\pi r_o h_c}} = \frac{100-25}{\frac{\ln\left(\frac{2.5}{0.5}\right)}{2\pi(0.5)} + \frac{1}{2\pi(2.5 \text{ x } 10^{-3})(10)}} = 10.90 \text{ W/m}$



93. Determine the critical radius in cm for an asbestos-cement covered pipe; k_{asb} = 0.208 W/m-°K. The external heat-transfer coefficient is 1.5 Btu/h-ft²-°F.

a) 2.44 cm b) 2.55 cm c) 2.66 cm d) 2.22 cm

Solution: $\text{Biot Number, } B_i = \frac{h_c r_o}{k_I} = \frac{10(2+0.5)10^{-3}}{0.5} = 0.05$

Solving for the Critical Radius: $r_c = \frac{k_I}{h_c} = \frac{0.208 \text{ W/m} \cdot {}^oK}{\left(1.5 \frac{Btu}{Hr \cdot ft^2 \cdot {}^oF}\right)\left(5.6751 \frac{W}{m^2 \cdot {}^oC}\right)} = 0.02443 \text{ m} = 2.44 \text{ cm}$

Note: $\left(1 \frac{Btu}{hr \cdot ft^2 \cdot {}^oF}\right) = \left(1 \frac{Btu}{hr \cdot ft^2 \cdot {}^oF}\right)\left(1055 \frac{J}{Btu}\right)\left(\frac{1 \text{ Hr}}{3600 \text{ s}}\right)\left(\frac{3.28 \text{ ft}}{1 \text{ m}}\right)^2\left(\frac{9}{5} {}^oF/{}^oC\right) = 5.6751 \frac{W}{m^2 \cdot {}^oC}$

94. Hot air flows, at an average temperature of 100 °C, through a 2.5-m-long tube with an inside diameter of 50 mm. The temperature of the pipe is 20 °C along its entire length. Convective film coefficient is 20.1 W/m²-°K. Determine the convective heat transfer from air to tube.

a) 631.46 W b) 641.36 W c) 661.43 W d) 663.14 W

Solution: Solving for the Convective Heat Transfer,

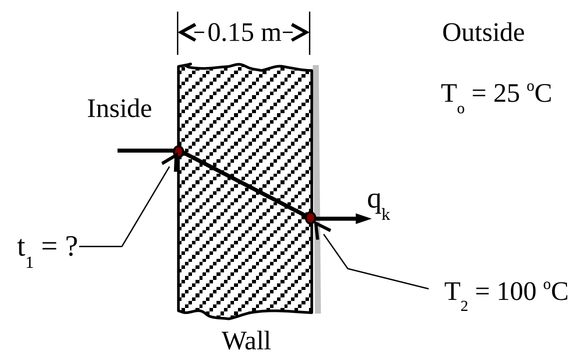
$$q_c = A h_c(\Delta T) = (\pi D_i L) h_c(\Delta T) = \pi(0.050\,m)(2.5 \text{ m})(20.1 \text{ W/m}^2 \cdot {}^oK)(100 - 20) = 631.46 \text{ W}$$

95. Under steady state conditions the outer surface of a furnace has a measured temperature of 100 °C. The hot combustion gases of a furnace are separated from the ambient air and its surrounding which are at 25 °C, by a brick wall 0.15 m thick. The brick has a thermal conductivity of 1.2 W/m-K and a surface emissivity of 0.80. Free convection heat transfer to the air adjoining this surface is characterized by a convection coefficient of 20 W/m²-K. What is the inner temperature?

a) 252.3 °C **b) 352.5 °C** c) 532.5 °C d) 325.5 °C

Answer: b) 352.5 °C

Solution: Since radiation Heat Transfer is considered: $\frac{q_k}{A} = \frac{q_c}{A} + \frac{q_r}{A}$



$$\frac{k(T_1 - T_2)}{x} = h_c(T_2 - T_o) + \varepsilon\sigma(T_2^4 - T_o^4)$$

$$\frac{(1.2 \text{ W/m} \cdot K)}{0.15\,m}(T_1 - 100) = \left(20 \frac{W}{m^2 \cdot K}\right)(100 - 25) + (0.80)\left(5.669 \text{ x } 10^{-8} \frac{W}{m^2 \cdot K^4}\right)\left[(100+273)^4 - (25+273)^4\right]$$

T_1 = 352.53 °C

Note: $\sigma = 5.669 \text{ x } 10^{-8} \frac{W}{m^2 \cdot {}^oK^4} = 0.1714 \text{ x } 10^{-8} \frac{Btu}{Hr \cdot ft^2 \cdot {}^oR^4} = \text{Stefan} \cdot \text{Boltzmann Cons tan t}$

96. Forced air flows over a convective heat exchanger in a room heater, resulting in a convective heat transfer coefficient h = 200 Btu/hr-ft²-°F. The surface temperature of heat exchanger may be considered constant at 150 °F, and the air is at 65 °F. Determine the heat exchanger surface area required for 30 000 Btu/h of heating.

a) 1.675 ft² **b) 1.765 ft²** c) 1.657 ft² d) 1.575 ft²

Answer: b) 1.765 ft^2

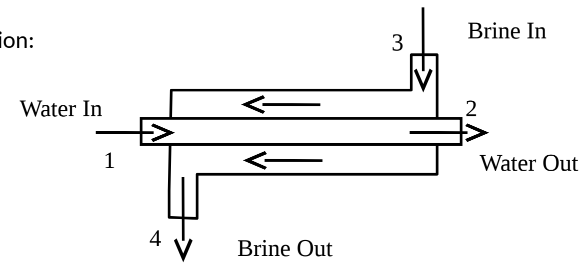
Solution: $$A = \frac{q_c}{h_c(\Delta T)} = \frac{30\,000 \text{ Btu/Hr}}{\left(200 \frac{\text{Btu}}{\text{Hr}\cdot\text{ft}^2\cdot{}^{o}\text{F}}\right)(150-65)} = 1.765 \text{ ft}^2$$

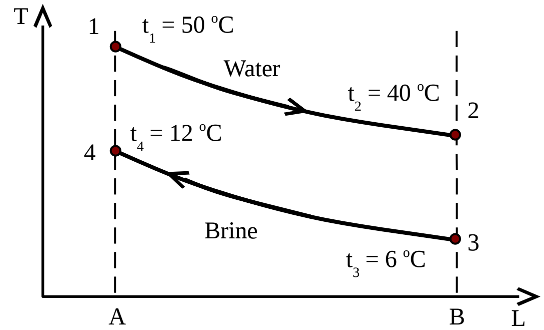
97. A brine solution is heated from 6 °C to 12 °C in a double-pipe heat exchanger by water entering at 50 °C and leaving at 40 °C at the rate of 0.166 kg/s. If the overall heat transfer coefficient is 850 W/m^2-°C, what heat exchanger area is required for counter flow?

a) 0.152 m^2 b) 0.173 m^2 **c) 0.221 m^2** d) 0.952 m^2

Answer: c) 0.221 m^2

Solution:





Heat rejected by the water: $q_w = m_w c_{pw}(T_1 - T_2) = (0.166 \text{ kg/s})(4.187 \text{ kJ/kg}\cdot\text{K})(50-40) = 6.95 \text{ kW}$

Terminal Temperature Difference and Log mean temperature difference, LMTD:

$$\theta_A = t_1 - t_4 = 50 - 12 = 38\ {}^{o}C \qquad \theta_B = t_2 - t_3 = 40 - 6 = 34\ {}^{o}C$$

$$LMTD = \frac{\theta_{max} - \theta_{min}}{\ln\left(\frac{\theta_{max}}{\theta_{min}}\right)} = \frac{38-34}{\ln\left(\frac{38}{34}\right)} = 36.99\ {}^{o}C$$

Solving for the surface Area: $A = \frac{q_k}{U(LMTD)} = \frac{6\,950}{(850)(36.99)} = 0.221 m^2$

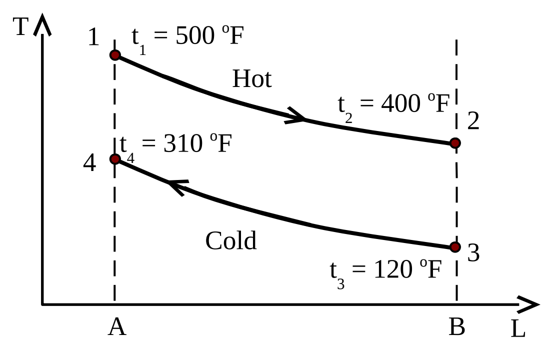
98. A liquid to liquid counter flow heat exchanger is used to heat a cold fluid from 120 °F and 310 °F. Assuming that the hot fluid enters at 500 °F and leaves at 400 °F, determine the LMTD for the heat exchanger.
a) 132 °F b) 332 °F **c) 232** °F d) 432 °F

Answer: c) 232 °F

Solution: $\theta_A = t_1 - t_4 = 500 - 310 = 190\ {}^{o}F$

$$\theta_B = t_2 - t_3 = 400 - 120 = 280\ {}^{o}F$$

$$LMTD = \frac{\theta_{max} - \theta_{min}}{\ln\left(\frac{\theta_{max}}{\theta_{min}}\right)} = \frac{280-190}{\ln\left(\frac{280}{190}\right)} = 232.1\ {}^{o}F$$



99. Consider a blackbody emitting at 1600 K. Determine the wavelength at which the blackbody spectral emissive power is maximum.
a) 1.329 μm b) 1.932 μm **c) 1.811μm** d) 1.181μm

Solution: From the Wien's Displacement Law,

$$\lambda_{max}T = 2897.6 \quad \circ\ \mu m \cdot K \quad \text{or} \quad \lambda_{max}T = 5215.6 \quad \circ\ \mu m \cdot {}^{o}R$$

$$\lambda_{max} = \frac{2897.6}{T} = \frac{2897.6}{1600} = 1.811\ \mu m$$

100. A blackbody filament is heated to 2300 K. What is the maximum radiative heat flux from the filament?
a) 1 586 418 W/m² b) 1 654 938 W/m² c) 2 586 418 W/m² d) 3 548 798 W/m²

Answer: a) 1 586 418 W/m²

Solution: $\frac{q_r}{A} = \varepsilon\sigma T^4 = (1.0)\left(5.669\ x\ 10^{-8}\ \frac{W}{m^2 \cdot K^4}\right)(2300\ K)^4 = 1586418.63\ \frac{W}{m^2}$

101. A huge blackbody enclosure has a small opening area of 1 cm². The radiative energy emitted by the opening is 5.67 W. Determine the temperature of the blackbody enclosure.
a) 1599 °K b) 1999 °K c) 1 200 °K **d) 1 000 °K**

Answer: d) 1000 K

Solution: $q_r = \varepsilon\,\sigma\, AT^4$ $\quad T = \left(\frac{q_r}{\varepsilon\,\sigma\, A}\right)^{\frac{1}{4}} = \left(\frac{5.67}{(1.0)(5.669\ x\ 10^{-8})(1\ cm^2)\left(\frac{1\ m}{100\ cm}\right)^2}\right)^{\frac{1}{4}} = 1000\ {}^{o}K$

102. Just after sunset, a man standing near a brick wall can sense radiant energy. Such walls frequently have surface temperatures around 44 °C, and typical brick emissivity values are on the order of 0.92. What would be the radiant thermal flux per square foot from a brick wall at this temperature?
a) 275 W/m² **b) 527 W/m²** c) 528 W/m² d) 529 W/m²

Answer: b) 527 W/m²

Solution: $\frac{q_r}{A} = \varepsilon\sigma T^4 = (0.92)\left(5.669\ x\ 10^{-8}\right)(44 + 273)^4 = 5.26.66\ W/m^2$

103. The filament of a 75-W light bulb may be considered a blackbody radiating into a black enclosure at 70 °C. The filament diameter is 0.10 mm, and the length is 5 cm. Considering only radiation, determine the filament temperature.
a) 3 030.54 °K **b) 3 029.54** °K c) 2 030.54 °K d) 3 028.54 °K

Answer: b) 3029.54 K

Solution: $A = \pi DL = \pi(0.0001 m)(0.05 m) = 1.5708\ x\ 10^{-5}\ m^2$ $\quad q_r = \varepsilon\sigma A\left(T_1^4 - T_2^4\right)$

$$75 = (1.0)\left(5.669\ x\ 10^{-8}\right)(\pi)(0.0001)(0.05)\left[T_1^4 - (70 + 273)^4\right]$$

T_1 = 3 029.54 °K

104. At point in a horizontal pipe line the pressure of water following at a velocity of 4.6 m/s is 117.3 kPaa; at another point close by, where the pipe has a smaller section, the pressure is 110.4 kPaa. If the head loss is 0.20 m, find the velocity of the second point.
a) 2.71 m/s **b) 1.85 m/s** c) 3.71 m/s d) 2.85 m/s

Answer: b) 1.85 m/s

Solution: p_2 = 110.4 kPaa $\quad V_1$ = 4.6 m/s $\quad p_1$ = 117.3 kPaa

Solving for V_2 if H_L = 0.20 m, using the Bernoulli's equation: $\frac{p_1}{\rho g} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\rho g} + z_2 + \frac{V_2^2}{2g} + H_L$

$$V_2 = \sqrt{\frac{2(p_2 - p_1)}{\rho} + V_1^2 - 2gH_L} = \sqrt{\frac{2(110400 - 117300)}{1000} + (4.6)^2 - 2(9.8066)(0.20)} = 1.85\ m/s$$

105. A manometer tube contains 60 % water and 40 % alcohol (SG = 0.80). What is the manometer fluid height difference if a 6.2 psi pressure is applied across the two ends of a manometer?

a) 214.62 inches b) 316 inches c) 151 inches d) 18.6 inches

Answer: a) 214.62 inches

Solution: $h = \frac{p}{\gamma} = \frac{(6.2)(144)}{(0.80)(62.4)} = 12.885\,ft = 214.62\ inches$

106. A closed circular pipe of 17 inches inside diameter, carries a 3300 gpm of water flow. If the friction is 0.03, determine the expected head loss per mile of the pipe.

a) 0.007 ft b) 0.647 ft **c) 37.76 ft** d) 35.80 ft

Answer: c) 37.76 ft

Solution: Q = 3300 gpm = 208.197 lps = 0.208197 m^3/s =7.3468 ft^3/s 1 mile = 5280 ft

$$V = \frac{4Q}{\pi D^2} = \frac{4(7.3468)}{\pi\left(\frac{17}{12}\right)^2} = 4.66\ fps$$

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = (0.03)\left(\frac{5280}{\frac{17}{12}}\right)\frac{(4.663)^2}{2(32.2)} = 37.75\ ft$$

107. From feed water at 80 °C (h_f = 334.9 kJ/kg), steam at a pressure of 0.90 MPaa (h_f = 743 kJ/kg, h_{fg} = 2031 kJ/kg) is generated in an exhaust gas boiler. If the dryness factor of the steam is 0.95, determine the heat transfer per kg steam.

a) 3237.55 kJ/kg **b) 2337.55 kJ/kg** c) 2733.55 kJ/kg d) 2755.33 kJ/kg

Answer: b) 2337.55 kJ/kg

Solution: $h_2 = h_{f2} + x_2 h_{fg2} = 743 + 0.96(2031) = 2672.45\ kJ/kg$

$$q = \Delta h = h_2 - h_1 = 6272.45 - 334.9 = 2337.55\ kJ/kg$$

108. A 150-MW power plant produced an annual energy of 500 000 MW-hrs. Calculate the annual capacity factor of the plant.

a) 38.05 % b) 35.08 % c) 30.85 % d) 53.08 %

Solution: $\text{Annual Capacity Factor} = \frac{\text{Annual Energy Produced, kW}\cdot\text{Hrs}}{(\text{Plant Capacity, kW})(8760\ \text{Hrs})}$

$$ACF = \frac{500\ 000\ 000}{150\ 000(8760)} = 0.3805,\ \text{or}\ 38.05\ \%$$

109. A power plant is said to have a use factor of 48.5 % and a capacity factor of 42.4 %. How many hours did it operate during the year?
a) 6 758.23 Hrs **b) 7 658.23 Hrs** c) 5 768.23 Hrs d) 8 765.23 Hrs

Solution: $\text{Use Factor} = \frac{\text{Annual kW}\cdot\text{Hr}}{(\text{kW Plant Capacity})(\text{Number of Hrs of Operation})}$

$$\text{No. of Hrs of operation} = \left(\frac{\text{Capacity Factor}}{\text{Use Factor}}\right)(8\,760) = \left(\frac{0.424}{0.485}\right)(8760) = 7\,658.23\ \text{Hrs}$$

110. A feed having 18 % moisture delivers 150 kg/min of dried product having 97 % solid. Find the moisture removed.
a) 21.25 kg/min **b) 27.44 kg/min** c) 17.44 kg/min d) 22.15 kg/min

Answer: b) 27.44 kg/min

Solution: $m_1(1 - MC_1) = m_2(1 - MC_2)$ $\quad m_1 = \frac{m_2(1 - MC_2)}{1 - MC_1} = \frac{150(1 - 0.03)}{1 - 0.18} = 177.44\ kg/min$

$$\Delta m = m_1 - m_2 = 177.44 - 150 = 27.44\ kg/min$$

111. An open cylindrical tank having a radius of 0.30 m and a height of 1.20 m is filled with water at a depth of 0.90 m. How fast will it be rotated about its vertical axis so that no water will be spilled out?

a) 178,34 rpm | b) 207.22 rpm | **c) 109.21 rpm** | d) 66.88 rpm

Answer: c) 109.21 rpm

Solution: $y = \dfrac{\omega^2 r^2}{2g}$ $\quad 0.60 = \dfrac{\omega^2 (0.30)^2}{2(0.81)}$ $\quad \omega = 11.44 \text{ rad/s}$ $\quad N = \dfrac{11.44(60)}{2\pi} = 109.21 \text{ rpm}$

112. The gravimetric analysis of the dry exhaust gas from an internal combustion engine is as follows: CO_2 = 20 %; O_2 = 5 %; N_2 = 75 %. Determine the specific heat gas constant in kJ/kg-°K.

a) 0.2780 | b) 0.2652 | c) 2.0776 | **d) 0.2735**

Answer: d) 0.2735

Solution: Total Number of moles: $n_t = \dfrac{0.20}{44} + \dfrac{0.05}{32} + \dfrac{0.75}{28} = 0.0329 \text{ kgmol}$

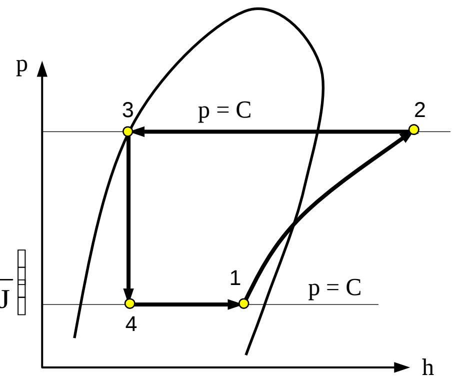
Gas Constant: $R = n_t \overline{R} = (0.0329 \text{ kgmol})(8.3143 \text{ kJ/kgmol} \cdot {}^{o}K) = 0.2735 \text{ kJ/kg} \cdot {}^{o}K$

113. A refrigerator using ammonia has a pressure in the evaporator is 2.74 kg/cm^2 and the ammonia at entry is 0.12 dry while at exit is 0.91 dry. During compression the work done per kg of ammonia is 17033 kg-m. Calculate the COP. It is given that the latent enthalpy and specific volume of ammonia at 2.24 kg/cm^2 are 320 kcal/kg and 0.436 m^3/kg, respectively.

a) 4.63 | **b) 6.34** | c) 3.46 | d) 4.36

Answer: b) 6.34

Solution: $h_{fg} = (320 \text{ kCal/kg})(4.187 \text{ kJ/kCal}) = 1339.84 \text{ kJ/kg}$



$$h_4 = h_f + x_4(h_{fg}) = h_f + (0.12)(1339.84) = h_f + 160.78$$

$$h_1 = h_f + x_1(h_{fg}) = h_f + (0.91)(1339.84) = h_f + 1219.25$$

$$w_c = h_2 - h_1 = \left[17\,033 \ \frac{kg_f \cdot m}{kg}\right](9.8066 \ N/kg_f)\left[1\frac{J}{N \cdot m}\right]\left[\frac{1 kJ}{1000 \ J}\right]$$
$$= 167.04 \text{ kJ/kg}$$

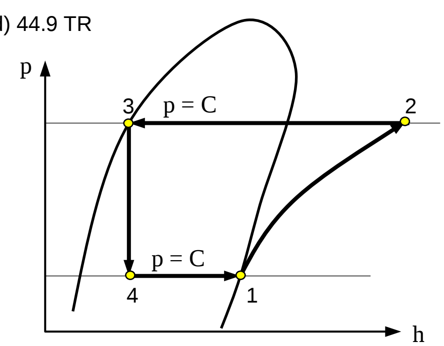
$$COP = \frac{Q_e}{W_c} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{1219.25 - 160.78}{167.04} = 6.34$$

114. In an ideal vapor-compression using R-12 with an evaporator temperature of 49.3 °C and requires a 74.6 kW motor to drive the compressor. What is the capacity of the refrigerator in TR? From R-12 Table: h_2 = 382 kJ/kg, h_3 = 243.15 kJ/kg, h_4 = 243.15 kJ/kg, & h_1 = 338.14 kJ/kg.

a) 49.5 TR | **b) 45.9 TR** | c) 43.9 TR | d) 44.9 TR

Answer: b) 45.9 TR

Solution: Solving for the capacity of refrigerator, TR



$$m = \frac{W_c}{h_2 - h_1} = \frac{74.6}{382 - 338.14} = 1.70 \text{ kg/s}$$

$$Q_e = \frac{m(h_1 - h_4)}{3.516} = \frac{(1.70)(338.14 - 243.15)}{3.517} = 45.91 \text{ TR}$$

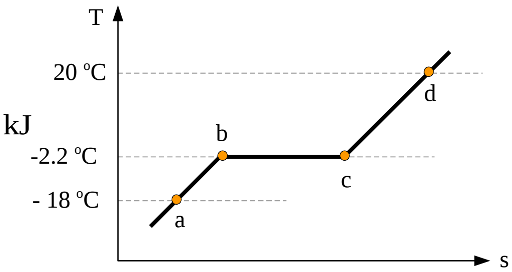
115. A lean beef if it is to be cooled from 20 °C to 4 °C, after which it is frozen and cooled to – 18 °C. Compute the heat to be removed from 110 kg of lean beef to achieve this requirement. Specific heat of beef above freezing is given as 3.23 kJ/kg-°C and below freezing is 1.68 kJ/kg-°C, freezing point is – 2.2 °C, and latent heat of fusion is 233 kJ/kg.

a) 40 319 kJ | **b) 36 437.5 kJ** | c) 42 329 kJ | d) 37 438 kJ

Answer: b) 36 437.5 kJ

Solution: $q = m\left[c_{p_{dc}}(\Delta T)_{dc} + h_i + c_{pba}(\Delta T)_{ba}\right]$

$$q = (110)\left[3.23(20+2.2) + 233 + 1.68(-2.2+18)\right] = 36\,437.5 \text{ kJ}$$



116. In a reversed Carnot cycle, the minimum and maximum temperatures are – 25 °C and 72 °C, respectively. If the heat rejected at the condenser is 6000 kJ/min, determine the power input required.

a) 28.12 kW b) 27.81 kW c) 31.11 kW d) 28.06 kW

Answer: a) 28.12 kW

Solution: $COP = \frac{T_L}{T_H - T_L} = \frac{273-25}{72-25} = 5.28$ $Q_L = Q_H\left(\frac{T_L}{T_H}\right) = \left(\frac{6000}{60}\right)\left(\frac{273-25}{72+273}\right) = 71.88 \text{ kW}$

$$W = Q_H - Q_L = \left(\frac{6000}{60}\right) - 71.88 = 28.12 \text{ kW}$$

117. In a reversed Carnot cycle, the minimum and maximum temperatures are minus 24 °C and 72 °C, respectively. If the heat rejected at the condenser is 6000 kJ/min, determine the power input required.

a. 25 KW b. 26 KW **c. 28 KW** d. 30 KW

Answer: c) 28 kW

Solution: $Q_L = Q_H\left(\frac{T_L}{T_H}\right) = \left(\frac{6000}{60}\right)\left(\frac{273-24}{72+273}\right) = 72.12 \text{ kW}$ $W = Q_H - Q_L = \left(\frac{6000}{60}\right) - 72.12 = 27.88 \text{ kW}$

118. A refrigerating system operates on the Reversed Carnot cycle. The higher temperature of the refrigeration system is 49°C and the lower temperature is -12°C. The capacity is 30 tons. Neglect all losses, determine the horsepower input.
a. 23 b. 28 **c. 33** d. 39

Answer: c) 33.04 Hp

Solution: $COP = \frac{T_L}{T_H - T_L} = \frac{273-12}{49+12} = 4.28$ $W = \frac{Q_e}{COP} = \frac{30(3.516)}{4.28(0.746)} = 33.04 \text{ Hp}$

119. A refrigeration system operates on the Reversed Carnot cycle with a refrigerant higher temperature of 50°C. The COP is 5 and the capacity is 50 tons. Determine the change of entropy in KJ/min-K.
a. 39.2 b. 32.0 c. 92.3 d. 23.9

Answer: a) 39.2 kJ/min-°K

Solution: $T_L = \frac{COP(T_H)}{1+COP} = \frac{5(50+273)}{1+5} = 269.2\ ^oK$

$$\Delta S = \frac{Q_e}{T_L} = \frac{50(3.516)}{269.2} = 0.653 \text{ kW}/^o\text{K} = 39.18 \text{ kJ}/\text{min}\cdot{}^o\text{K}$$

120. A refrigeration system operates on the Reversed Carnot cycle with a refrigerant higher temperature of 50°C. The COP is 5 and the capacity is 50 tons. If the cycle works as a heat pump, what is its COP?
a. 5 b. 5.5 **c. 6** d. 6.5

Answer: c) 6

Solution: $COP_{HP} = COP_{Ref} + 1 = 5 + 1 = 6$

121. A simple vapor compression cycle develops 70.32 KW of refrigeration using ammonia refrigeration at 24°C condenser temperature (h_f = 312.87 KJ/kg) and an evaporator temperature of minus 18°C (h_g = 1439.94 KJ/kg). If the enthalpy of the refrigerant leaving compressor is 1657 KJ/kg. What is the required power per ton of refrigeration (KW/ton)?
a. 0.766 b. 0.667 **c. 0.676** d. 0.776

Answer: c) 0.675 kW/TR

Solution: $$COP = \frac{h_1 - h_4}{h_2 - h_1} = \frac{1439.94 - 312.87}{1657 - 1439.94} = 5.2 \qquad kW / Ton = \frac{3.517}{COP} = \frac{3.517}{5.2} = 0.676$$

Note: $$COP = \frac{Q,\ TR}{W, kW} = \frac{TR\,(3.517)}{kW} \quad \rightarrow \quad \frac{kW}{TR} = \frac{3.517}{COP}$$

122. An NH_3 compressor operates at an evaporator pressure of 316 KPa and condenser pressure of 1514.2 KPa. A twin-cylinder compressor with the bore and stroke unity is to be used at 1200 rpm. Assuming a 5% clearance for the compressor and the refrigerant volume flow rate at compressor suction of 0.0322 m^3/sec, determine the size of the compressor in mm.

a) 105 b) 95 c) 110 d) 125

Answer: a) 105 mm

Solution: $$\eta_v = \left[1 + c - c\left(\frac{p_2}{p_1}\right)^{\frac{1}{k}}\right](100\ \%) = \left[1.05 - 0.05\left(\frac{1514.2}{316}\right)^{\frac{1}{1.304}}\right](100\ \%) = 88.37\ \%$$

$$V_D = \frac{V_1}{\eta_v} = \frac{0.0322}{0.8837} = 0.0364\,m^3/s \qquad V_D = \left(\frac{\pi}{4}\right)D^2 Lnn_c / 60 = \left(\frac{\pi}{4}\right)D^3\left(\frac{n}{60}\right)n_c$$

$$D = \left[\frac{4(60)V_D}{\pi n n_c}\right]^{\frac{1}{3}} = \left[\frac{4(60)(0.0364)}{\pi(1200)(2)}\right]^{\frac{1}{3}} = 0.10503\ m = 105.03\ mm$$

123. Calculate the TR required to cool 15,000 lbs of fresh pork from a temperature of 89°F to 32°F in 24 hours. Specific heat above freezing of fresh pork is 0.68 Btu/lb-°F and the fresh pork freezing temperature is 28.4°F.

a) 2.02 b) 3.52 c) 1.68 d) 5.64

Answer: a) 2.02 TR

Solution: $$Q_e = \left[\frac{15\,000}{24(60)(200)}\right](0.68)(89 - 32) = 2.02\ TR$$

Note: 1 TR = 12 000 Btu/hr = 200 Btu/min

124. A full cylindrical tank 12 m high has a constant diameter of 6 m. The tank has a 100 mm diameter hole in its bottom. The coefficient of discharge for the hole is 0.98. How long will it take for the water level to drop from 12 m to 6 m?
a) 16 minutes b) 20 minutes **c) 24 minutes** d) 28 minutes

Answer: c) the time to lower the level = 24 minutes

Solution: $$V_o = C_v\sqrt{2gH} = (0.98)\sqrt{2(9.8066)(12)} = 15.035\ m/s$$

$$V_T = \frac{\pi}{4}D^2h = \left(\frac{\pi}{4}\right)(6)^2(12 - 6) = 169.65\ m^3$$

$$Q = AV_o = \left(\frac{\pi}{4}\right)d^2V_o = \left(\frac{\pi}{4}\right)(0.10)^2(15.035) = 0.1181\ m^3/s \quad t = \frac{V_T}{Q} = \frac{169.65}{0.1181(60)} = 23.94\ \text{minutes}$$

125. An air-vapor mixture has a DB temperature of 30 ºC and a humidity ratio of 0.015 kg/kg d.a. Calculate the enthalpy.
a) 68.527 kJ/kg d.a. b) 78.527 kJ/kg d.a. c) 58.527 kJ/kg d.a. d) 88.527 kJ/kg d.a.

Answer: a) 68.527 kJ/kg d.a.

Solution: $h = 1.007t - 0.026 + W(2501 + 1.84t) = (1.007)(30) - 0.026 + (0.015)[2501 + 1.84(30)] = 68.527 \text{ kJ/kg}$

126. What is the moisture content of moist air at 20 °C DB, 15 °C WB, and 95 kPa barometric pressure? Let the saturation pressure of water at 15 °C equals to 1.7057 kPaa and at 20 °C is 2.339 kPaa.

a) 0.00923 kg/kg d.a. b) 0.00293 kg/kg d.a. c) 0.00392 kg/kg d.a. d) 0.00239 kg/kg d.a.

Answer: a) 0.00923 kg/kg d.d Solution: Using the IHVE formula to solve for p_v,

$$p_v = p_{WB} - 6.66 \times 10^{-4} p_t (DB - WB) = 1.7057 - (6.66 \times 10^{-4})(95)(20 - 15) = 1.38935 \text{ kPaa}$$

$$W = (0.622)\frac{p_v}{p_t - p_v} = 0.622\left[\frac{1.38935}{95 - 1.38935}\right] = 0.00923 \text{ kg/kg da.}$$

127. A 6 m^3 tank is filled with a nitrogen gas at a pressure of 198.675 kPag and temperature of 40 °C. Determine the mass of the nitrogen in the tank.

a) 18.4 kg **b) 19.4 kg** c) 20.4 kg d) 17.4 kg

Answer: b) 19.4 kg

Solution: $R = \frac{\bar{R}}{M} = \frac{8.3143}{28} = 0.29694 \text{ kJ/kg} \cdot {}^o K$ $\quad m = \frac{pV}{RT} = \frac{(198.675 + 101.325)(6)}{0.29694(40 + 273)} = 19.4 \text{ kg}$

128. It is a form of thermal convection when the motion of the fluid is due entirely to buoyancy forces, usually confined to a layer near the heated or cooled surface. How do you call this thermal convection mode of heat transfer?
a) Free Convection b) Force Convection c) Transient Convection d) Normal Convection

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130. What are the refrigerants that are chlorofluorocarbons but cause little ozone destruction?
a) CFC Refrigerants **b) HCFC Refrigerants** c) HFC Refrigerants d) Inorganic Refrigerants

131. What is the refrigerant commonly used in ice-plant refrigeration?
a) R –12 b) R – 22 c) **Ammonia** d) R – 40

132. What do you call a refrigeration system in which the refrigerant gas evolved in the evaporator is taken up in an absorber and released in a generator upon the application of heat?
a) Absorption refrigeration system b) Cascade refrigeration system
c) Flooded refrigeration system d) Steam jet refrigeration system

133. Which of the following is true for white ice?
a) A fast-cooled water b) A sub-cooled water
c) Due to dissolved air, gases and impurities d) Formed by blowing air during freezing

134. In the detection of refrigerant leak, sulphur stick burning in the presence of ammonia will release of which of the following colors of smoke?
a) Dense White b) Dense Yellow c) Dense Orange d) Dense Red

135. It is the ozone-destroying power of a substance measured relative to refrigerant 11 (R-11 or CFC-11).
a) Ozone Depletion Potential (ODP) b) Hydrochlorofluorocarbon (HCFC)
c) Hydrofluorocarbon (HFC) d) Global Warming Potential (GWP)

136. How do you classify a solenoid valve?
a) A thermal valve **b) A magnetic stop valve** c) A bellows valve d) A bi-metallic valve

137. What is a thermostat?
a) A temperature-operated switch b) A pressure-operated switch
c) A superheat-operated switch d) A back pressure-operated switch

138. Which of the following ranges of humidity ratio is used for comfort air conditioning?
a) 50 to 55 % **b) 55 to 60 %** c) 60 to 65 % d) 45 to 50 %

139. What is a body insulation that is usually described as a single equivalent uniform layer over the whole body?
a) Skin b) Blood **c) Clothing** d) Water

140. The amount of heat required or needed to raise the temperature of one pound of the substance one degree Fahrenheit.
a) Specific heat b) Internal energy c) Latent heat d) All the above

141. The amount of heat added to or removed from a substance that can be measured by a change in temperature of the substance.
a) Specific heat **b) Sensible heat** c) Latent heat d) Internal energy

142. The amount of heat added to or removed from a substance to cause a change of state without a change in temperature.
143. a) Specific heat b) Sensible heat **c) Latent heat** d) Internal energy

144. The amount of heat needed to change a substance from solid to the liquid state.
a) Specific heat **b) Latent heat of fusion** c) Latent heat of vaporization d) Heat of conduction

145. The amount of heat required to change a substance from the liquid to the vapor state.
a) Specific heat b) Latent heat of fusion **c) Latent heat of vaporization** d) Heat of conduction

146. The value of latent heat of vaporization for one lb water at standard atmospheric pressure.
a) 970 Btu b) 2257 Btu c) 144 Btu d) 335 Btu

147. The amount of latent heat of fusion for one lb water at standard atmospheric pressure.
a) 970 Btu b) 2257 Btu **c) 144 Btu/** d) 335 Btu/lb

148. The unit of heat in the English system of units.
a) Btu b) ft-lb c) Hp d) ft-lb/mn

149. What is the unit of work in the English system?
a) Btu **b) Ft-lb** c) Ft-lb/min d) Btu/min.

150. As a general rule, the cooling water side of the condenser should be scheduled for inspection every which of the following number of months?
a) Month b) **3 Months** c) 6 Months d) Year

151. When adding the refrigerant in a refrigeration system, it shall be charge into which of the following parts of the system?
a) High pressure side **b) Low pressure side** c) Low and high pressure side d) Compressor discharge line

152. Which of the following is not a desirable property of a refrigerant?
a) Low thermal conductivity b) Low freezing point c) Low condensing pressure d) Low viscosity

153. It is the process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the comfort requirements of the occupants of the conditioned room or space. What is this?
a) Comfort Air Conditioning b) Summer Air Conditioning c) Industrial Air Conditioning d) Commercial Air Conditioning

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a) A thermal valve **b) A magnetic stop valve** c) A bellows valve d) A bi-metallic valve

165. What is a thermostat?
a) A temperature-operated switch b) A pressure-operated switch
c) A superheat-operated switch d) A back pressure-operated switch

166. Which of the following ranges of humidity ratio is used for comfort air conditioning?
a) 50 to 55 % **b) 55 to 60 %** c) 60 to 65 % d) 45 to 50 %

167. What is a body insulation that is usually described as a single equivalent uniform layer over the whole body?
a) Skin b) Blood **c) Clothing** d) Water

168. The amount of heat required or needed to raise the temperature of one pound of the substance one degree Fahrenheit.
a) Specific heat b) Internal energy c) Latent heat d) All the above

169. The amount of heat added to or removed from a substance that can be measured by a change in temperature of the substance.
a) Specific heat **b) Sensible heat** c) Latent heat d) Internal energy

170. The amount of heat added to or removed from a substance to cause a change of state without a change in temperature.
171. a) Specific heat b) Sensible heat **c) Latent heat** d) Internal energy

172. The amount of heat needed to change a substance from solid to the liquid state.
a) Specific heat **b) Latent heat of fusion** c) Latent heat of vaporization d) Heat of conduction

173. The amount of heat required to change a substance from the liquid to the vapor state.
a) Specific heat b) Latent heat of fusion **c) Latent heat of vaporization** d) Heat of conduction

174. The value of latent heat of vaporization for one lb water at standard atmospheric pressure.
a) 970 Btu b) 2257 Btu c) 144 Btu d) 335 Btu

175. The amount of latent heat of fusion for one lb water at standard atmospheric pressure.
b) 970 Btu b) 2257 Btu **c) 144 Btu/** d) 335 Btu/lb

176. The unit of heat in the English system of units.
a) Btu b) ft-lb c) Hp d) ft-lb/mn

177. What is the unit of work in the English system?
a) Btu **b) Ft-lb** c) Ft-lb/min d) Btu/min.

178. An instrument used to measure the DB-temperature and the wet-Bulb temperature of moist air.
a) Phsycrometer b) Thermometer c) Hydrometer d) Hygrometer

179. How do you call the pressure, in psi, above a complete vacuum?
a) Gage pressure **b) Absolute pressure** c) Vacuum pressure d) Atmospheric pressure

180. A temperature in which moisture content of moist air starts to condense.
a) Wet-bulb temperature b) Dry-bulb temperature **c) Dew point temperature** d) Saturation temperature

181. For each gas there exists a temperature above which it cannot be liquefied, regardless of pressure. This temperature is called as ____________.
a) Wet-bulb temperature b) Dry-bulb temperature **c) Critical temperature** d) Saturation temperature

182. Thee co called ______________ at substances used in laboratory methods of producing a drop in temperature.
a) Brine mixture b) Water-ammonia mixture **c) Frigorific mixture** d) Ice and salt mixture

183. Adding 10 percent salt (N_aCl), by weight, to water lowers its freezing point from 32 °F to ___________.
a) 18.7 °F b) 0 °F c) 15.7 °F d) 32 °F

184. It is the basis of all refrigeration calculations, whether for old storage, air conditioning, ice cram manufacturing.
a) Refrigerating effect **b) Ton of refrigeration** c) Coefficient of performance d) Compressor Hp

185. Which of the following is the component of vapor-compression refrigeration not belonging to high pressure side?
a) Condenser b) Compressor **c) Expansion valve** d) Liquid line

186. Another term for suction pressure.
a) Discharge pressure b) Heat pressure **c) Back pressure** d) Condenser pressure

187. The amount of heat absorbed in the evaporator, which is the same as the amount of heat removed from the space to be cooled.
a) Tons of refrigeration **b) Refrigerating effect** c) Coefficient of performance d) Compressor Hp

188. Too much oil in th compressor would ____________.
a) Absorb too much refrigerant from the system b) Damage the expansion valve
c) Cause leakage through the shaft seals d) Deposit oil on the condenser tube

189. Which of the following has the lowest boiling point or temperature?
a) NH_3 **b) CO_2** c) F-22 d) F-21

190. Which of the following would cause a high suction pressure?
a) Expansion valve not open wide enough **b) Expansion valve open too wide**

c) King valve not open wide enough c) Dirty dehydrator

191. Which of the following would cause high head pressure or condenser pressure?
a) Dirty condenser b) Insufficient cooling water
c) Pressure of air in the cooling water **d) All of these**

192. Which of the following would cause low head pressure?
a) Insufficient cooling water b) Too much cooling water
c) Insufficient refrigerant gas **d) Too much cooling water and or insufficient refrigerant gas**

193. The dehydrator is located __________________.
a) Between the receiver and king valve b) Between the receiver and expansion valve
c) Between the condenser and king valve d) Between the condenser and accumulator

194. Which of the following is the purpose or function of the dehydrator?
a) To remove oil from the refrigerant b) To add more refrigerant to the system
c) To remove moisture from the refrigerant d) To remove moisture from the crank case oil

195. Which of the following would you apply if you got Freon in your yes?
a) Soapy water **b) Sterile mineral oil** c) Clean water d) Sodium bicarbonate

196. What is the heart of th refrigeration system?
a) Condenser b) Evaporator **c) Compressor** d) Expansion valve

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c) Insufficient refrigerant gas **d) Too much cooling water and or insufficient refrigerant gas**

212. Water in the refrigerant is liable to _______________.
a) Clog the oil trap b) Freeze in the king valve
c) Emulsify the oil in the compressor d) To freeze on the expansion seat and cut the flow of liquid refrigerant

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b) Between the receiver and expansion valve
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d) Between the condenser and accumulator

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d) To freeze on the expansion seat and cut the flow of liquid refrigerant

218. The purpose of the scale trap is _______________.
a) To control the amount of scale going to the compressor
b) To remove insoluble gases from the refrigerant
c) To remove dirt, scale and metal chips from the refrigerant
d) To dissolve scale and dirt in the system

219. What is the function of expansion valve?
a) To regulate the amount of liquid refrigerant to the expansion coils
b) To change the high-pressure liquid to low-pressure liquid
c) To change the gas refrigerant to liquid
d) To shut off the flow of refrigerant to the condenser

220. The oil separator or oil trap is located between _____________.
a) Receiver and the king valve
b) Condenser and the receiver
c) Compressor discharge valve and the condenser
d) Receiver and the king valve

221. The purpose of the oil trap or oil separator is _________________
a) To remove oil from the refrigerant gas
b) To remove oil from the charging tank
c) To add oil to the compressor
d) To remove oil from the evaporator

222. Which of the following is the boiling point of ammonia at standard atmospheric pressure?
a) – 28 ºC
b) – 28 ºF
c) 0 ºF
d) 32 ºF

223. The purpose of the scale trap is _______________.
a) To control the amount of scale going to the compressor
b) To remove insoluble gases from the refrigerant
c) To remove dirt, scale and metal chips from the refrigerant
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c) Compressor discharge valve and the condenser
d) Receiver and the king valve

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b) To remove oil from the charging tank
c) To add oil to the compressor
d) To remove oil from the evaporator

227. When adding the refrigerant in a refrigeration system, it shall be charge into which of the following parts of the system?
a) High pressure side
b) Low pressure side
c) Low and high pressure side
d) Compressor discharge line

228. Which of the following is not a desirable property of a refrigerant?
a) Low thermal conductivity
b) Low freezing point
c) Low condensing pressure
d) Low viscosity

229. It is the process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the comfort requirements of the occupants of the conditioned room or space. What is this?
a) Comfort Air Conditioning
b) Summer Air Conditioning
c) Industrial Air Conditioning
d) Commercial Air Conditioning

230. A double-pipe condenser has:
a) two piping system side by side, one with cooling water and one with refrigerant
b) a small pipe inside a larger pipe, the cooling water passing through the small pipe and the refrigerant through the large pipe
c) two pips for cooling water and one for the refrigerant
d) none of the above

231. Air can be prevented from getting into the system by:
a) keeping all glands and stuffing boxes on the high-pressure side tight
b) keeping the dehydrator clean at all times
c) keeping all glands and stuffing boxes on the low-pressure side tight
d) running the refrigerant through the aerator

232. Which of the following is the boiling point of ammonia at standard atmospheric pressure?

a) – 28 ºC **b) – 28 ºF** c) 0 ºF d) 32 ºF

233. "The total volume of a mixture of gases is equal to the sum of the volumes that would be occupied by the various components each at the pressure and temperature of the mixture." What does the preceding statement refer to?
a) Amagat's law b) Dalton's law of partial pressure c) Charles' law d) Boyle's law

234. Dual cycle is also known as:
a) Constant pressure regenerative cycle **b) Limited-pressure cycle**
c) Constant volume and constant pressure combustion cycle d) Constant volume combustion cycle

235. In a cooling tower, what is the difference in temperatures between the hot water entering and the cold water leaving the cooling tower?
a) Theoretical Cooling Range **b) Actual Cooling Range** c) Terminal difference d) Actual Cooling effect

236. How do you call an external air or an atmosphere exterior to refrigerated or conditioned space?
a) Saturated air b) Moist air **c) Outside air** d) Indoor air

237. It is a condition of air wherein the partial pressure of the water vapor is equal to the vapor pressure of water at the existing temperature. What is this condition of air?
a) Moist air b) Dry air **c) Saturated air** d) Conditioned air

238. It is defined as the ratio of the weight or mass of water vapor to the weight or mass of dry air. How do you call this ratio?
a) Relative humidity **b) Specific humidity** c) Specific volume d) Percent saturation

239. It is an air conditioning device in which water circulates continuously, and the spray provides so much surface area that the air leaves the spray chamber in equilibrium with water, with respect to both temperature and vapor pressure. The walls of the device are insulated that no heat is added to or extracted from the water line. What is this air conditioning device?
a) Air washer b) Cooling and dehumidifying Apparatus c) Cooler battery **d) Adiabatic saturator**

240. Adiabatic saturation process is an air conditioning process that is theoretically:
a) Constant dry bulb temperature **b) Constant wet bulb temperature**
c) Constant enthalpy d) Constant dew point temperature

241. It is an assembly of equipment for the treatment of air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of a conditioned. How do you call this equipment?
a) Refrigeration Unit **b) Air conditioning unit** b) Air Washer d) Cooling and dehumidifying Apparatus

242. These cooling towers have the fans are located at the top and draw the air upward through the tower. How do you call this cooling tower?
a) Natural Draft Cooling Tower b) Mechanical Draft Cooling Tower
c) Forced Draft-fan Cooling Tower **d) Induced Draft-fan Cooling Tower**

243. Which of the following does not belong to the factors affecting the rate of heat transfer in a cooling tower?
a) The difference between the air wet-bulb temperature and the water temperature b) The area of water surface exposed to the air
c) The relative velocity of the air and water **d) The size of the induced draft fan**

244. This is a computer or hand calculation procedure where energy requirements are determined at many outdoor temperature conditions; it is used for the energy calculations of air conditioning systems. What is this method?
a) Calculator Method b) Dalton Method c) Carrier Method **d) Bin Method**

245. It is an envelope area with significantly higher rate of heat transfer than the contiguous enclosure. How do you call this?
a) Thermal Bridge b) Thermal Radiation c) Thermal Surface d) Thermal area

246. This is the transport of energy by mixing in addition to conduction; it is associated with fluids in motion, generally through a pipe or duct or along a surface. How do you call this mode of heat transfer?
a) Free Convection b) Force Convection c) Transient Convection **d) Thermal Convection**

247. It is an environmental heat stress index that combines the dry-bulb temperature, a naturally ventilated wet bulb temperature, and the globe temperature. What is this?
a) Wet-bulb globe temperature b) Wind chill index c) Effective temperature d) Sol-air temperature

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a) Wet-bulb globe temperature **b) Wind chill index** c) Effective temperature d) Sol-air temperature

249. It is defined as the temperature of a uniform environment at 0 % relative humidity in which a person losses the same total amount of heat from the skin as in the actual environment. What is this temperature?
a) Adiabatic equivalent temperature b) Wind chill index c) Effective temperature d) Sol-air temperature

250. How do call an instrument that measures temperature by electromotive force?
a) Thermocouple b) Mercury thermometer c) Radiation pyrometer d) Optical pyrometer

251. What is the quantity of heat required to change the state of a body without an increase in temperature?
a) Heat of vaporization b) Sensible heat c) Specific heat **d) Latent heat**

252. How do you call a fire involving flammable liquids and gases?
a) Class A fire **b) Class B fire** c) Class C fire d) Class D fire

253. Which of the following is not a main part of a typical coal burner?
a) Air registers b) A nozzle **c) An atomizer** d) An igniter

254. Which of the following is the purpose of the nozzle in a combustor of gas turbine plant?
a) Increase the velocity b) Increase the pressure c) Increase the moisture d) Increase the power

255. When the number of reheat stages in a reheat cycle is increased, the average temperature:
a) Increases b) Constant c) **Decreases** d) Zero

256. What is a valve designed to allow the fluid to pass through in one direction only?
a) Solenoid valve **b) Check valve** c) Gate valve d) Globe valve

257. It is the difference in pressure measured below or above atmospheric pressure. How do you call this?
a) Draft b) Drift c) Gage pressure d) Atmospheric pressure

258. What do you call a minute-fresh water plant growth that forms a scum on the surfaces of re-circulated water apparatus, interfering with fluid flow and heat transfer?
a) Algae b) Water lily c) Bacteria d) Virus

259. This is a water supply system or device for cleaning, humidifying, or dehumidifying the air. How do you call this device?
a) Air lateral b) Air main c) Air tunnel **d) Air washer**

260. This is a circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes, and arranged to promote mixing of primary air with secondary room air. What is this component?
a) Air nozzle **b) Air diffuser** c) Air conduit d) Air duct

261. Which of the following is an instrument for measuring the velocity of the fluid?
a) Analyzer b) Anticipating control c**) Anenometer** d) Air washer

262. A steam power plant in which the exhaust from the prime mover, which may be either a reciprocating steam engine or a turbine, is discharged into a condenser in which the absolute pressure is less than atmospheric.
a) Non-condensing steam power plant **b) Condensing power plant**
c) Regenerative cycle power plant d) Co-generative power plant

263. Which of the following is true for the design of an air duct supply of an air conditioning?
a) Adds moisture to the air b) Lowers temperature of the air c) Does not affect the moisture of air **d) Affects the distribution of air**

264. What do you call a simultaneous generation of electricity and steam (or heat) in a single steam power plant?
a) Steam turbine plant **b) Cogeneration** c) Gas turbine plant d) Waste heat recovery

265. Which of the following is the process occurring in a cooling tower?
a) Sensible heating **b) Heating and humidifying** c) Adiabatic saturation d) Chemical dehumidification

266. Which of the following occurs when pumps are connected in parallel?
a) Increase head, same discharge b) No change
c) Increase discharge, same head d) Increase discharge, increase head

267. It indicates the water level inside the boiler. What is this?
a) Water column b) Water walls c) Baffles d) Fusible plug

268. What is the ratio of the maximum demand of the system to the rated capacity of the system?
a) Operation factor **b) Utilization factor** c) Annual capacity factor d) Use factor

269. Which of the following is the most commonly used pyrometer?
a) Optical b) Radiation **c) Thermoelectric** d) Bimetallic

270. This is pipe is attached to the penstock to let the water be at atmospheric pressure. How do you call this?
a) Draft tube **b) Surge chamber** c) Spillway d) Silt sluice

271. Which of the following is not considered as gaseous fuel?
a) Acetylene b) Liquefied petroleum gas **c) Bunker** d) Propane

272. If the volume of an ideal gas is inversely proportional with its absolute pressure at a constant-temperature process. The preceding statement is known as:
a) Boyle's Law b) Charles' Law c) Joule's Law d) Newton's Law

273. How do you call the heat energy produced by the movement of the molecules within a substance caused by its temperature?
a) Molecular energy **b) Internal energy** c) Kinetic energy d) Entropy

274. In a steam generator, what do you call the duct that connects the boiler to the chimney?
a) Breeching b) Blowdown valve c) Gage glass d) Baffles

275. In relation to brakepower, what is the instrument used to measure the torque?
a) Tachometer b) Engine indicator c) Anemometer **d) Dynamometer**

276. What is the ratio of the radiation of an actual body to the radiation of a blackbody?

a) Absorptance **b) Emittance** c) Reflectance d) Transmittance

277. This valve positions the valve spool to admit the refrigerant as required by evaporator load.
a) Thermostatic Expansion Valve b) Electric Expansion Valve c) Capillary tube d) Short Tube Restrictor

278. This is not a valve, but effectively replaces the expansion valve in many applications. It is a long thin tube placed between the condenser and the evaporator. The small diameter and long length of the tube produce a large pressure drop.
a) Thermostatic Expansion Valve b) Electric Expansion Valve **c) Capillary tube** d) Short Tube Restrictor

279. This is widely used in place of capillary tube in residential systems. It has high reliability, low cost, and easily inspected and replaced.
a) Thermostatic Expansion Valve b) Electric Expansion Valve c) Capillary tube **d) Short Tube Restrictor**

280. It is used to maintain a relatively constant minimum pressure in the evaporator.
a) Evaporator Pressure Regulator b) Suction Pressure Regulator c) Short Tube Restrictor d) Short tube restrictor

281. The main application of evaporator pressure regulator:
a) To set a minimum evaporator temperature to permit the use of different evaporators at different pressures on the same compressor.
b) Used for limiting the maximum pressure at compressor suction
c) It reduces the compressor load during the start-up period
d) All of these

282. The main advantage of the capillary tube:
a) It has high reliability, low cost, and easily inspected and replaced **b) Its simplicity and low cost; and it is not subject to wear**
c) It is a load-limiting device d) All of these

283. A (n) ______________ wrench should b used on a valve stem.
a) Allen wrench b) Miniature pipe **c) Service valve** d) Torx key

284. When should you push and pull on a wrench?
a) Push to loosen, pull to tighten b) Pull to loosen, push to tighten c) Always push d) Always pull

285. What tool should not be used on a slotted hexagon head bolt?
a) Straight screw driver **b) Nut pliers** c) Hex key wrench d) Twelve-point wrench

286. Which of the following would not describe a box wrench?
a) Straight b) Offset c) Double offset d) Open ended

287. It is a branch of science that deals with the process of reducing and maintaining the temperature of a space or material below the temperature of the surroundings.
a) Air conditioning **b) Refrigeration** c) Heat pumping d) All of these

288. The high-pressure vapor heat exchanger in the refrigeration system.
a) Evaporator **b) Condenser** c) Boiler d) Heater

289. A refrigeration method of lowering and maintaining the temperature of a material or space by the use of a literal ice (water or other substance, say, dry ice)
a) Ice Refrigeration b) Mechanical Refrigeration c) Vacuum Refrigeration d) Air cycle Refrigeration

290. A method of refrigeration using air as refrigerant, and basically used for the air conditioning of aircraft.
a) Ice Refrigeration b) Mechanical Refrigeration c) Vacuum Refrigeration **d) Air cycle Refrigeration**

291. It is a compressor that has a single or multi-stage high-speed impeller to set up enough centrifugal force within a circular casing to raise the pressure of the refrigerant gas to condensing level.
a) Reciprocating compressor b) Rotary compressor **c) Centrifugal compressor** d) Sliding vane compressor

292. It is a positive displacement compressor that traps a given volume of gas, compresses it, and ejects from the machine. It usually has a rotor revolving off-center in a cylinder with sliding vanes forced against the cylinder wall. Refrigerant gas is compressed by the sliding vanes around the cylinder from suction port to the discharge port.
a) Reciprocating compressor b) Rotary compressor c) Centrifugal compressor **d) Rotary sliding vane compressor**

293. This compressor is another positive displacement compressor, and was first used for refrigeration in the late 1950s. The compressor basically consists of two mating helically grooved rotors, a male (lobes) and female (grooves), in a stationary housing with suction and discharge ports.
a) Reciprocating compressor **b) Rotary screw compressor** c) Centrifugal compressor d) Rotary sliding vane compressor

294. It is a compressor with crankshaft extended through the compressor housing in which the motor is externally coupled to the shaft. Ammonia compressors are manufactured only in this type.
a) Open-type Compressor b) Hermetic Compressor
c) Semi-hermetic compressor d) Welded-shell (sealed) Hermetic Compressor

295. In air conditioning, it indicates either a volume or a site without a partition or a partitioned room or group of rooms. How do you call this?
a) Zone b) Room **c) Space** d) Plenum

296. It is an enclosed or partitioned space that is usually treated as a single load. If conditioned, it often has an individual control system. What is this?
a) Zone **b) Room** c) Space d) Plenum

297. Which of the following parameters has the greatest limiting effect on the thermal performance of an open, evaporative cooling tower?
a) Wet-Bulb temperature b) Dry-Bulb temperature c) Range c) Approach

298. A method of refrigeration system using water as refrigerant; lowering and maintaining of system temperature is attained by creation of vacuum condition through the action of steam jet. It is basically used in the air condition system of a steam power plant.
a) Ice Refrigeration b) Mechanical Refrigeration **c) Vacuum Refrigeration** d) Air cycle Refrigeration

299. These cooling towers have the fans are located at the top and draw the air upward through the tower. How do you call this cooling tower?
a) Natural Draft Cooling Tower b) Mechanical Draft Cooling Tower
c) Forced Draft-fan Cooling Tower **d) Induced Draft-fan Cooling Tower**

300. It is the term referring to any glazed aperture in a building envelope; the components of which include the following: glazing material, either glass or plastic; framing, mullions, muntins, and dividers; external shading devices; and integral-shading systems (between glass). What is this?
a) Infiltration b) Radiation **c) Fenestration** d) Transmission

301. The most common instrument used to determine the mean radiant temperature; it consists of a hollow sphere 6 inches in diameter, flat black paint coating, and a thermocouple or thermometer bulb at its center.
a) Psychrometer b) Thermocouple c) Kelvin thermometer **d) Vernon's globe thermometer**

302. This is a refrigeration system having two or more refrigerant circuits, each with a condenser, evaporator, and a pressure-imposing element, where the evaporator of one circuit cools the condenser of the other circuit. How do you call this refrigeration system?
a) Absorption Refrigeration b) Split-type Refrigeration c) Vacuum Refrigeration **d) Cascade Refrigeration**

303. What kind of a heat exchanger where water is heated to a point that dissolved gases is liberated?
a) Evaporator b) Condenser c) Intercooler **d) Deaerator**

304. This is a circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes, and arranged to promote mixing of primary air with secondary room air. What is this component?
a) Air nozzle **b) Air diffuser** c) Air conduit d) Air duct

305. It is a space, or several rooms, or units of space having some sort of coincident loads or similar operating characteristics. It may or may not be an enclosed space, or it may consist of many partitioned rooms. How do you call this?
a) Zone b) Room c) Space d) Plenum

306. The capacity of an evaporative condenser will:
a) increase as the entering air wet-bulb temperature decreases b) increase as the entering air wet-bulb temperature increases
c) not change with changes in the line/entering air wet-bulb temperature d) decrease as the entering air wet-bulb temperature decreases

307. Gas condenses in the anal or inner tube of a(n):
a) atmospheric condenser **b) double-pipe condenser** c) shell-and-tube condenser d) evaporative condenser

308. Natural-draft condensers are most frequently in:
a) residential cooling b) room air conditioners **c) household refrigerators** d) large industrial plants

309. The capacity of an evaporative condenser is greatest on a:
a) warm day b**) low-humidity day** c) cool day d) rainy day

310. The capacity of an evaporative condenser depends on:
a) fan horsepower **b) entering-air wet-bulb temperature**
c) the temperature of the entering air d) the amount of heat leaving air is capable of absorbing

311. The following does not increase the capacity of a water-cooled condenser:
a) increasing the water flow b) reducing the water temperature
c) decreasing the ambient temperature d) none of the above

312. Open shell-and-tube condensers are mainly used with:
a) a cooling tower of spray pond **b) a dirty water** c) chemically treated water d) hard water

313. If a shell-and-tube condenser were removed and an evaporative condenser were installed, city water consumption would:
a) decrease 40 to 50% b) increase 40 to 50% c) increase 85 to 90% d) decrease 85 to 90%

314. A cooling tower:
a) is always used if water is scarce **b) is an accessory to a condenser**
c) helps the operator maintain pressures d) must be in a location where the prevailing wind blows

315. Of the many ways to control condensing pressure, one method *not* an evaporative condenser is:
a) cycling spray pump motor **b) coil flooding** c) air-bypass duct and damper d) air-throttling damped inlet

316. If a system operated with suction stop valve closed and the discharge stop valve open, what would happen?
a) the head would blow off b) high head pressure would occur
c) non-condensible gases would enter **d) all of the above**

317. At a given temperature, the relation of the actual pressure of a vapor in the atmosphere to the saturation pressure is called:
a) relative humidity b) partial pressure c) humidifying effect d) refrigeration effect

318. The capacity of a water-cooled condenser is least affected by:
a) the amount of water circulated b) the temperature of the water
c) the amount of gas circulated **d) the ambient temperature**

319. What effect would a refrigeration overcharge have on the system?
a) head pressure would increase b) head pressure would be decrease

320. How do you call a line that shows the relation of the steam consumption and the load of a steam turbine-generator?

a) Newton's line b) Dalton's line c) Jonval's line **d) Willan's line**