INSTRUCTION: Solve the following **very important problems**.

1. Compute the specific volume of an air-vapor mixture in cubic meters per kilogram of dry air when the following conditions prevail : t = 30°C, w = 0.015 kg/kg, and P_t = 90 kPa.
   A. 0.99 m^3/kg * C. 0.79 m^3/kg
   B. 0.89 m^3/kg D. 0.69 m^3/kg
2. Compute the humidity ratio of air considering the density at 35°C and 101 kPa is 1.05 kg/m^3.
   A. 0.036 kg_{vapor} / kg_{air} * C. 0.36 kg_{vapor}/kg_{air}
   B. 0.063 kg_{vapor} / kg_{air} D. 0.63 kg_{vapor}/kg_{air}
3. A coil has an inlet temperature of 60°F and outlet of 90°F. If the mean temperature of the coil is 110°F, find the bypass factor of the coil.
   A. 0.20 C. 0.40 *
   B. 0.30 D. 0.50
4. Compute the pressure drop of 30°C air flowing with a mean velocity of 8 m/s in a circular sheet-metal duct 300 mm in diameter and 15 m long. Use a friction factor, f = 0.02, and ρ_{air} = 1.1644 kg/m^3.
   A. 37.26 Pa * C. 29.34 Pa
   B. 25.27 Pa D. 30.52 Pa
5. A pressure difference of 350 Pa is available to force 20°C air through a circular sheet-metal duct 450 mm in diameter and 25 m long. At 20°C, ρ = 1.204 kg/m^3 and take friction factor, f = 0.016. Determine the velocity.
   A. 25.57 m/s * C. 28.54 m/s
   B. 27.55 m/s D. 24.85 m/s
6. A duct 0.40 m high and 0.80 m wide suspended from the ceiling in a corridor, makes a right angle turn in the horizontal plane. The inner radius is 0.2 m and the outer radius is 1.0 m measured from the same center. The velocity of air in the duct is 10 m/s. Compute the pressure drop in this elbow. Assuming ; f = 0.3, ρ = 1.204 kg/m^3 and L = 10 m.
   A. 341 Pa * C. 143 Pa
   B. 441 Pa D. 144 Pa
7. A rectangular duct has a dimensions of 0.25 m by 1 m. Determine the equivalent diameter of the duct.
   A. 0.40 m * C. 0.70 m
   B. 0.80 m D. 0.30 m
8. Find the amount of electrical energy expended raising the temperature of 45 liters of water by 75°C. Assume the efficiency of the heating equipment to be 90% ?
   A. 3.44 kW-hr C. 4.36 kW-hr *
   B. 2.45 kW-hr D. 10.45 kW-hr
9. To what height will a barometer column rise if the atmospheric conditions are 13.9 psia and 68°F and barometer fluid is mercury?
   A. 28.3 in. * C. 35.6 inches
   B. 22.45 n D. 32.45 inches
10. To what height will a barometer column rise if the atmospheric conditions are 13.9 psia and 68°F and barometer fluid is ethyl alcohol? Note: @ 68°F ; P_v = 122.4 lbf/ft^2 and specific gravity of 0.79 for ethyl alcohol.
    A. 457.45 in. * C. 435.6 inches
    B. 422.45 n D. 132.45 inches
11. To what height will 68°F ethyl alcohol rise in a 0.005 inch internal diameter glass capillary tube? The density of alcohol is 49 lbm/ft^3. where: β = 0° = contact angle and surface tension σ = 0.00156 lbf/ft @ 68°F.
    A. 0.3056 ft * C. 0.4312 ft
    B. 0.2504 ft D. 0.2432 ft
12. What is the velocity of sound in 150°F (66°C) air at a standard pressure? Note: density of air @ 150°F is 0.064 lbm/ft^3
    A. 1295 ft/s * C. 2345 ft/s
    B. 3245 ft/s D. 1096 ft/s
13. What is the pressure 8000 ft below the water surface of the ocean? Neglect compressibility.
    A. 512,000 psf * C. 157,000 psf
    B. 324,500 psf D. 213,000 psf
14. If atmospheric air 14.7 psia and 60°F at sea level, what is the pressure at 12000 ft altitude if air is incompressible. Note: @ 60°F ; the density of air is 0.0763 lbm/ft^3 ; P_1 = 14.7 psia
    A. 5.467 psia C. 8.342 psia *
    B. 9.345 psia D. 2.346 psia
15. If atmospheric air 14.7 psia and 60°F at sea level, what is the pressure at 12000 ft altitude if air is incompressible.
    Note: @ 60°F ; the density of air is 0.0763 lbm/ft^3 ; P_1 = 14.7 psia
    A. 5.467 psia C. 8.342 psia
    B. 9.53 psia * D. 2.346 psia
16. A cylindrical 1 ft diameter , 4 ft high tank contains 3 ft of water. What rotational speed is required to spin water out the top?
    A. 22.7 rad/s * C. 22.7 rad/s
    B. 32.5 rad/s D. 34.5 rad/s
17. Water (ρ = 62.4 lbm/ft^3) is flowing through a pipe. A pitot-static gage registers 3.0 inches of mercury. What is the velocity of the water in the pipe? Note: ρ_{Hg} = 848.6 lbm/ft^3
    A. 14.24 ft/s * C. 8.24 ft/s
    B. 11.24 ft/s D. 7.45 ft/s
18. A two-pass surface condenser is to be designed using overall heat transfer coefficient of 480 Btu/°F-ft^2 of outside tube surface. The tubes are to be 1 inch outside diameter with 1/16 in walls (or 7/8 in. inside diameter). Entering circulating water velocity is to be 6 ft/s. Steam enters the condenser at a rate of 100,000 lb/hr at a pressure of one psia and an enthalpy of 1090 Btu/lb. Condensate leaves at saturated liquid at one psia. Circulating water enters the condenser at 85 deg. F and leaves at 95 deg F. Note: 1 psia condensate has temperature of 101.7 deg. F. Wet steam entering becomes condensate at 101.7 deg. F with hf = 69.72 Btu/lb. Calculate the total number of tubes to be used in each pass.
    A. 18,200 tubes * C. 10,450 tubes
    B. 15,400 tubes D. 11,456 tubes
19. A two-pass surface condenser is to be designed using overall heat transfer coefficient of 480 Btu/°F-ft^2 of outside tube surface. The tubes are to be 1 inch outside diameter with 1/16 in walls (or 7/8 in. inside diameter). Entering circulating water velocity is to be 6 ft/s. Steam enters the condenser at a rate of 100,000 lb/hr at a pressure of one psia and an enthalpy of 1090 Btu/lb. Condensate leaves at saturated liquid at one psia. Circulating water enters the condenser at 85 deg. F and leaves at 95 deg F. Note: 1 psia condensate has temperature of 101.7 deg. F. Wet steam entering becomes condensate at 101.7 deg. F with hf = 69.72 Btu/lb. Calculate the total length of the tube to be used in ft.
    A. 123,000 ft C. 742,000 ft *
    B. 324,000 ft D. 543,000 ft
20. A two-pass surface condenser is to be designed using overall heat transfer coefficient of 480 Btu/°F-ft^2 of outside tube surface. The tubes are to be 1 inch outside diameter with 1/16 in walls (or 7/8 in. inside diameter). Entering circulating water velocity is to be 6 ft/s. Steam enters the condenser at a rate of 100,000 lb/hr at a pressure of one psia and an enthalpy of 1090 Btu/lb. Condensate leaves at saturated liquid at one psia. Circulating water enters the condenser at 85 deg. F and leaves at 95 deg F. Note: 1 psia condensate has temperature of 101.7 deg. F. Wet steam entering becomes condensate at 101.7 deg. F with hf = 69.72 Btu/lb. Calculate the total length of the tube to be used in ft per tube.
    A. 20.4 ft * C. 17.4 ft
    B. 80.8 ft D. 15.5 ft
21. A 0.30 x 0.40 m branch duct leaves a 0.30 x 0.60 main duct at an angle of 60°. The air temperature is 20°C. The dimensions of the main duct remain constant following branch. The flow rate upstream is 2.7 m^3/s. What is the pressure downstream in the main duct. Note: at 20°C, ρ = 1.2041 kg/m^3.
    A. 346 Pa * C. 634 Pa
    B. 436 Pa D. 643 pa
22. A sudden enlargement in a circular duct measures 0.20 m diameter upstream and 0.40 m downstream. The upstream pressure is 150 Pa, downstream pressure is 200 Pa. What is the flow rate of 20°C air through the fitting? Use ρ = 1.02041 kg/m^3.
    A. 0.49 m^3/s C. 0.38 m^3/s *
    B. 0.83 m^3/s D. 0.94 m^3/s
23. Determine the sensible heat of 5 lb of air having a dry bulb temperature of 70°F and a humidity ratio of 0.0092 lb/lb, the latter corresponding to a dew point temperature of approximately 55°F.
    A. 94 BTU C. 84 BTU *
    B. 48 BTU D. 49 BTU
24. Determine the approximate load on a cooling tower if the entering and leaving temperatures are 96°F and 88°F, respectively and the flow rate of the water over the tower is 30 gpm.
    A. 2500 Btu/min C. 3000 Btu/min
    B. 2000 Btu/min * D 3500 Btu/min
25. Determine the quantity of water lost by bleed off if the water flow rate over the tower is 30 gpm and the range is 10°F. Percent bleed-off required is 33%.
    A. 0.077 gpm C. 0.099 gpm *
    B. 0.088 gpm D. 0.066 gpm
26. The mass of an outside air at 50°C in an air conditioning unit is 60 kg. Ifnd the temperature after mixing if the outside air mixed with 40 kg with recirculated air at 35°C.
    A. 44°C * C. 52°C
    B. 39°C D. 47°C
27. A creamery must cool 20,000 liters of milk received each day from initial temperature of 29°C to a final temperature of 2°C in 5 hours. If

refrigeration losses amount to 10 percent of the cooling load, what must be the capacity of the refrigerating machine?
Note: Specific heat of milk if 3.9 kJ/kg-K and S.G. = 1.05.
A. 38.5 TOR *
B. 36.5 TOR
C. 37.5 TOR
D. 39.5 TOR

28. How many tons of refrigeration are required to produce 10 metric tons of ice per day at −10°C from raw water at 22°C if miscellaneous losses are 15% of the chilling and freezing load?
A. 17 TOR *
B. 20 TOR
C. 15 TOR
D. 24 TOR

29. Five hundred kilograms of poultry enter a chiller at 8°C and are frozen and chilled to a final temperature of -18°C for storage in 15 hours. The specific heat above and below freezing are 3.18 kJ/kg°C and 1.55 kJ/kg°C respectively. The latent heat is 246 kJ/kg and the freezing temperature is -5°C. Compute the product load.
A. 2.75 kW
B. 2.85 kW *
C. 2.95 kW
D. 3.15 kW

30. Fish weighing 11,000 kg with a temperature of 20°C is brought to a cold storage and which shall be cooled to -10°C in 11 hours. Find the required plant refrigerating capacity in tons of refrigeration if the specific heat of fish os 0.7 kCal/kg°C above freezing and 0.30 kCal/kg°C below freezing point which is -3°C. The latent heat of freezing is 55.5 kCal/kg.
A. 25.26
B. 15.26
C. 14.38
D. 24.38 *

31. Mass of ice at -4°C is needed to cool 115 kg of vegetables in a bunker for 24 hours. The initial temperature of vegetables is assumed to be 30°C. It is also assumed that the average temperature inside the bunker is 7°C within 24 hour period. If the heat gained per hour in the bunker is 30% of the heat removed to cool the vegetable from 30°C to 7°C, what would be the required mass of ice ?
Note: Specific heat of ice = 1.935 kJ/kg-K
Specific heat of vegetables = 3.35 kJ/kg-K
Specific heat of water = 4.186 kJ/kg-K
Heat of fusion of ice = 335 kJ/kg
A. 27.86 kg *
B. 26.57 kg
C. 29.54 kg
D. 37.48 kg

32. A refrigerator is 2 m high, 1.2 m wide and 1 m deep. The over-all heat transfer coefficient is 0.532 W/m² °C. How many kilograms of 0°C ice will melt per hour if the inside temperature is maintained at 10°C while the surrounding air temperature is at 35°C ?
A. 1.60 kg *
B. 1.80 kg
C. 2.60 kg
D. 2.80 kg

33. The power requirement of a Carnot refrigerator in maintaining a low temperature region at 300 K is 1.5 kW per ton. Find the heat rejected.
A. 4.02 kW
B. 7.02 kW
C. 5.02 kW *
D. 6.02 kW

34. A vapor compression refrigeration system is designed to have a capacity of 150 tons of refrigeration. It produces chilled water from 22°C to 2°C. Its actual coefficient of performance is 5.86 and 35% of the power supplied to the compressor is lost in the form of friction and cylinder cooling losses. Determine the condenser cooling water required for a temperature rise of 10°C.
A. 14.75 kg/s *
B. 15.65 kg/s
C. 18.65 kg/s
D. 13.75 kg/s

35. Cold salt brine at an initial temperature of 0°C is used in a packing plant to chill beef from 40°C to 5°C in 18 hours. Determine the volume of brine in liters per minute required to cool 1000 beeves of 250 kg each, if the final temperature of brine is 3°C. Specific heat of brine is 3.76 kJ/kg°C and S.G. = 1.05. Specific heat of beef is 3.14 kJ/kg°C.
A. 37.59 kg/s *
B. 39.67 kg/s
C. 38.79 kg/s
D. 35.67 kg/s

36. Four thousand liters per hour of distillates are to be cooled from 21°C to - 12°C and 12% of wax by weight is separated out at 15°C. The specific heat of oil is 2 kJ/kg°C and S.G. is 0.87. The specific heat of the wax is 2.5 and the latent heat of fusion is 290 kJ/kg. Allow 10% for the losses, find the capacity of the refrigerating machine.
A. 20 TOR
B. 51.08 TOR
C. 40 TOR
D. 31.08 TOR *

37. Determine the heat extracted from 2000 kg of water from 25°C to ice at − 10°C.
A. 621,150 kJ
B. 721,150 kJ
C. 821,150 kJ
D. 921,150 kJ *

38. A single acting, twin cylinder, Ammonia compressor with bore equal to stroke is driven by an engine at 250 rpm. The machine is installed in a chilling plant to produce 700 kW of refrigeration at -18°C evaporating temperature. At this temperature the cooling effect per kg mass is 1160 kJ. The specific volume of vapor entering the compressor is 0.592 m³ per kilogram. Assume 85% volumetric efficiency, determine the bore in mm.
A. 400 mm *
B. 300 mm
C. 450 mm
D. 500 mm

39. A cylindrical flash tank mounted with its axis horizontal is used to separate liquid ammonia from ammonia vapor. The ammonia vapor bubbles through the liquid with 70 m³/ min leaving the disengaging surface. The disengaging rate is limited to 60 m/min and the liquid level is to operate with the liquid level one-third of the diameter from the top. Determine the diameter if the tank is 1.5 m long.
A. 830 mm *
B. 730 mm
C. 860 mm
D. 760 mm

40. A 150 Hp motor is used to drive a compressor. If the heat loss from the compressor is 25 kW and the mass flow rate of the refrigerant entering the compressor is 0.50 kg/s, determine the difference of the enthalpies between the inlet and outlet of the compressor.
A. 143.80 kJ/kg
B. 153.80 kJ/kg
C. 173.80 kJ/kg *
D. 183.80 kJ/kg

41. To cool farm products, 300 kg of ice at − 4.4°C are placed in bunker. Twenty four hours later the ice have melted into water at 7.2°C. What is the average rate of cooling provided by the ice in kJ/hr ?
A. 2679.28 kJ/hr
B. 5679.28 kJ/hr
C. 3679.28 kJ/hr
D. 4679.28 kJ/hr *

42. Determine the estimated condenser load for an open-type compressor having a cooling capacity of 16,500 Btu/hr and a heat rejection factor of 1.32.
A. 22,280 Btu/hr
B. 20,780 Btu/hr
C. 21,780 Btu/hr *
D. 19,780 Btu/hr

43. If the load on water-cooled condenser in 150,000 Btu/hr and the temperature rise of the water in the condenser is 10°F, what is the quantity of water circulated in gpm?
A. 30 *
B. 40
C. 20
D. 50

44. The load on a water-cooled condenser is 90,000 Btu/hr. If the quantity of water circulated through the condenser is 15 gpm, determine the temperature rise of the water in the condenser.
A. 12°F *
B. 14°F
C. 16°F
D. 18°F

45. The weight of ammonia circulated in a machine is found to be 21.8 lb/hr. If the vapor enters the compressor with a specific volume of 9.6 ft³/lb, calculate the piston displacement, assuming 80% percent volume efficiency.
A. 261.6 ft³/hr *
B. 271.6 ft³/hr
C . 281.8 ft³/hr
D. 291.6 ft³/hr

46. A single-stage ammonia compressor is producing 10 tons of refrigeration and the power consumed is 15 Hp. Suction pressure is 25 psi, condensing pressure is 180 psi. Brine temperature is 20°F off brine cooler. Determine the actual coefficient of performance.
A. 10.14
B. 11.14 *
C. 12.14
D. 13.14

47. In an ammonia condensing machine (compressor plus condenser) the water used for condensing is 55°F and the evaporator is at 15°F. Calculate the ideal COP.
A. 11.875 *
B. 12.875
C. 10.875
D. 13.875

48. How much refrigeration capacity is required to cool 2000 cfm of air from 85°F to 70°F ?
A. 2.7 TOR *
B. 3.7 TOR
C. 1.7 TOR
D. 4.7 TOR

49. Determine the coil face area required to maintain a face velocity of 400 ft/min if the air flow rate over the coil is 2100 ft³/min.
A. 3.25 ft²
B. 4.25 ft²
C. 5.25 ft² *
D. 6.25 ft²

50. Calculate the heat transfer per hour through a solid brick wall 6 m long, 2.9 m high, and 225 mm thick, when the outer surface is at 5°C and the inner surface 17°C, the coefficient of thermal conductivity of the brick being 0.6 W/m-K.
A. 2,004.48 kJ *
B. 3,004.48 kJ
C. 2,400.48 kJ
D. 3,400.48 kJ

51. A vertical furnace wall is made up of an inner wall of firebrick 20 cm thick followed by insulating brick 15 cm thick and an outer wall of steel 1 cm thick. The surface temperature of the wall adjacent to the combustion chamber is 1200°C while that of the outer surface of steel is 50°C. The thermal conductivities of the wall material in W/m-K are : firebrick, 10; insulating brick, 0.26; and steel , 45. Neglecting the film resistances and contact resistance of joints, determine the heat loss per sq.m. of wall area.
A. 1.93 W/m² *
C. 1.55 W/m²

B. 2.93 W/m² D. 2.55 W/m²

52. A composite 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 coefficients of the inside wall is 3.1 W/m²-K while that of the outside wall is 2.5 W/m²-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 high and 10 m long.
A. 330.10 W * C. 430.10 W
B. 230.10 W D. 530.10 W

53. One insulated wall of a cold-storage compartment is 8 m long by 2.5 m high and consists of an outer steel plate 18 mm thick. An inner wood wall 22.5 mm thick, the steel and wood are 90 mm apart to form a cavity which is filled with cork. If the temperature drop across the extreme faces of the composite wall is 15°C. Calculate the heat transfer per hour through the wall and the temperature drop across the thickness of the cork. Take the coefficients of thermal conductivity for steel, cork and wood as 45, 0.045, and 0.18 W/m-K respectively.
A. 408.24 kJ , 12.12°C C. 608.24 kJ, 13.12°C
B. 708.24 kJ , 11.12°C D. 508.24 kJ, 14.12°C *

54. A cubical tank of 2 m sides is constructed of metal plate 12 mm and contains water at 75°C. The surrounding air temperature is 16°C. Calculate the overall heat transfer coefficient from water to air. Take the coefficient of thermal conductivity of the metal as 48 W/m-K, the coefficient of thermal conductivity of the metal as 48 W/m-K, the coefficient of heat transfer of water is 2.5 kW/m²-K and the coefficient of heat transfer of the air is 16 W/m²-K.
A. 15.84 W/m²°C * C. 16.84 W/m²°C
B. 14.84 W/m²°C D. 13.84 W/m²°C

55. A cold storage compartment is 4.5 m long by 4 m wide by 2.5 m high. The four walls, ceiling and floor are covered to a thickness of 150 mm with insulating material which has a coefficient of thermal conductivity of 5.8 x 10^{-2} W/m-K. Calculate the quantity of heat leaking through the insulation per hour when the outside and inside face temperatures of the material is 15°C and -5°C respectively.
A. 2185.44 kJ * C. 3185.44 kJ
B. 1185.44 kJ D. 4185.44 kJ

56. A furnace wall consist of 35 cm firebrick (k = 1.557 W/m-K) , 12 cm insulating refractory (k = 0.346) and 20 cm common brick (k = 0.692) covered with 7 cm steel plate (k = 45) . The temperature at the inner surface of the firebrick is 1,230°C and at the outer face of the steel plate is 60°C. Atmosphere 27°C. What is the value of the combined coefficient for convection and radiation from the outside wall?
A. 31.13 W/m2-K C. 41.3 W/m2-K *
B. 30.13 W/m-K D. 40.13 W /m²-K

57. One side of refrigerated cold chamber is 6 m long by 3.7 m high and consists of 168 mm thickness of cork between outer and inner walls of wood. The outer wood wall is 30 mm thick and its outside face temperature is 20°C, the inner wood wall is 35 mm thick and its inside face temperature is -3°C. Taking the coefficient of thermal conductivity of cork and wood as 0.42 and 0.20 W/m-K respectively, calculate the heat transfer per second per sq. m of surface area.
A. 5.138 J * C. 6.318 J
B. 4.138 J D. 3.318 J

58. Hot gases at 280°C flow on one side of a metal plate of 10mm thickness and air at 35°C flows on the other side. The heat transfer coefficient of the gases is 31.5 W/m²-K and that of the air is 32 W/m²-K. Calculate the over-all transfer coefficient.
A. 15.82 W/m²-K * C. 14.82 W/m²-K
B. 16.82 W/m²-K D. 17.82 W/m²-K

59. The surface temperature of the hot side of the furnace wall is 1200°C. It is desired to maintain the outside of the wall at 38°C. A 152 mm of refractory silica is used adjacent to the combustion chamber and 10 mm of steel covers the outside. What thickness of insulating bricks is necessary between refractory and steel, if the heat loss should be kept at 788 W/m² ? use k = 13.84 W/m-K for refractory silica; 0.15 for insulating brick, and 45 for steel.
A. 220 mm * C. 260 mm
B. 240 mm D. 280 mm

60. A hollow sphere has an outside radius of 1 m and is made of polystyrene foam with a thickness of 1 cm. A heat source inside keeps the inner surface 5.20°C hotter than the outside surface. How much power is produced by the heat source? The thermal conductivity of polystyrene foam is 0.033 W/m°C.
A. 200 W C. 300 W
B. 216 W * D. 316 W

61. An insulated steam pipe located where the ambient temperature is 32°C, has an inside diameter of 50 mm with 10 mm thick wall. The outside diameter of the corrugated asbestos insulation is 125 mm and the surface coefficient of still air, h_o = 12 W/m²-K. Inside the pipe is steam having a temperature of 150°C with film coefficient h_i = 6000 W/m²-K. Thermal conductivity of pipe and asbestos insulation are 45 and 0.12 W/m-K respectively. Determine the heat loss per unit length of pipe.
A. 110 W C. 130 W
B. 120 W * D. 140 W

62. A pipe 200 mm outside diameter and 20 m length is covered with a layer, 70 mm thick of insulation having a thermal conductivity of 0.05 W/m-K and a thermal conductance of 10 W/m²-K at the outer surface If the temperature of the pipe is 350°C and the ambient temperature 15°C, calculate the external surface temperature of the lagging.
A. 32.6°C * C. 42.6°C
B. 22.6°C D. 53.6°C

63. A copper rod whose diameter is 2 cm and length 50 cm has one end in boiling water, the other end in a jacket cooled by flowing water which enters at 10°C. The thermal conductivity of the copper is 0.102 kCal/m-s-°C. If 0.20 kg of water flows through the jacket in 6 min, by how much does the temperature of the water increase?
A. 10.38°C * C. 11.38°C
B. 9.38°C D. 12.38°C

64. How many watts will be radiated from a spherical black body 15 cm in diameter at a temperature of 800°C ?
A. 5.34 kW * C. 6.34 kW
B. 4.34 kW D. 3.34 kW

65. A surface condenser serving a 50,000 kW steam turbo-generator unit receives exhaust steam at the rate of 196,000 kg/hr. Vacuum in condenser is 702 mm Hg. Sea water for cooling enters at 29.5°C and leaves at 37.5°C. For steam turbine condenser, manufacturers consider 950 Btu/lb of steam turbine condensed as heat given up to cooling water. Calculate the logarithmic mean temperature difference.
A. 4.57°C C. 6.57°C *
B. 5.57°C D. 7.57°C

66. A wall with an area of 10 m² is made of a 2 cm thickness of white pine (k= 0.113 W/m°C) followed by 10 cm of brick (k = 0.649 W/m°C). The pine is on the inside where the temperature is 30°C while the outside temperature is 10°C. Assuming equilibrium conditions exist, what is the temperature at the interface between the two metals?
A. 15.65°C C. 18.21°C
B. 17.64°C D. 19.31°C *

67. A counterflow heat exchanger is designed to heat fuel oil from 45°C to 100°C while the heating fluid enters at 150°C and leaves at 115°C. Calculate the arithmetic mean temperature difference.
A. 40°C C. 60°C *
B. 50°C D. 70°C

68. A pipe with an outside diameter of 2.5 in. is insulated with a 2 in. layer of asbestos (k_a = 0.396 Btu-in./hr-ft²-°F), followed by a layer of cork 1.5 in. thick (k_c = 0.30 Btu-in./hr-ft²-°F). If the temperature of the outer surface of the cork is 90°F, calculate the heat lost per 100 ft of insulated pipe.
A. 847.64 Btu/hr C. 2847.42 Btu/hr *
B. 3847.51 Btu/hr D. 1847.14 Btu/hr

69. With three different quantities x, y, and z of the same kind of liquid of temperatures 9, 21 and 38°C respectively, it is found that when x and y are mixed together the resultant temperature is 17°C and when y and z are mixed together the resultant temperature is 28°C. Find the resultant temperature if x and z were mixed.
A. 29.87°C C. 20.85°C
B. 25.92°C * D. 24.86°C

70. The journals of a shaft are 380 mm diameter, it runs at 105 rpm and the coefficient of friction between journals and bearings is 0.02. If the average load on the bearings is 200 kN, find the heat generated per minute at the bearings.
A. 501.375 kJ * C. 401.375 kJ
B. 505.575 kJ D. 501.575 kJ

71. A reverse Carnot cycle requires 3 Hp and extracts energy from a lake to heat a house. If the house is kept at 70°F and requires 2000 Btu per minute, what is the temperature of the lake ?
A. 35°F C. 39°F
B. 36°F * D. 40°F

72. An oxygen cylinder of volume 2.3 ft³ has a pressure of 2200 psig and is at 70°F. Determine the mass of oxygen in the cylinder.
A. 28.66 lbs * C. 26.88 lbs
B. 30.44 lbs D. 34.30 lbs

73. A group of 50 persons attend a secret meeting in room which is 12 m wide by 10 m long and a ceiling height of 3 m. The room is completely sealed off and insulated. Each person gives off 150 kCal per hour of heat and occupies a volume of 0.20 m^3. The room has an initial pressure of 101.3 kPa and temperature of 16°C. Calculate the room temperature after 10 minutes. Use R = 0.287 kJ/kg-K and C_v = 0.171 kCal/kg-K.
A. 33.1 °C *
B. 37.7 °C
C. 38.7 °C
D. 31.7 °C

74. The flow energy of 124 liters per minute of a fluid passing a boundary to system is 108.5 kJ/min. Determine the pressure at this point.
A. 875 kPa *
B. 675 kPa
C. 975 kPa
D. 575 kPa

75. Work done by a substance in reversible nonflow manner in accordance with V = 100/P ft^3, where P is in psia. Evaluate the work done on or by the substance as the pressure increases from 10 psia to 100 psia.
A. 33 157.22 ft-lb
B. –33 157.22 ft-lb *
C. 43 157.22 ft-lb
D. – 43, 157.22 ft-lb

76. The following expressions relate to a particular gaseous mass: PV = 95T, h = 120 + 0.60T where these units obtain in psf, V in ft^3/lb, T in °R and h in Btu/lb. If the specific heats are temperature dependent only, find C_p and C_v.
A. 0.6 Btu/lb°R, 0.48 Btu/lb°R *
B. 0.5 Btu/lb°R, 0.50 Btu/lb°R
C. 0.60 Btu/lb°R, 0.7 Btu/lb°R
D. 0.50 Btu/lb°R, 0.48 Btu/lb°R

77. Calculate the change in enthalpy as 1 kg of nitrogen is heated from 1000 K to 1500 K, assuming the nitrogen is an ideal gas at a constant pressure. The temperature dependent specific heat of nitrogen is $C_p = 39.06 - 512.79\,T^{-1.5} + 1072.7\,T^{-2} - 820.4T^{-3}$ where C_p is in kJ/kg-mol, and T is in K.
A. 600 kJ
B. 697.27 kJ *
C. 800 kJ
D. 897.27 kJ

78. One kilogram of wet steam at a pressure of 8 bar (v_g = 0.2404 m^3/kg, v_f = 0.0011148 m^3/kg) and dryness 0.94 is expanded until the pressure is 4 bar (v_g = 0.4625 m^3/kg, v_f = 0.0010836 m^3/kg). If expansion follows the law $PV^n = C$, where n = 1.12, find the dryness fraction of the steam at the lower pressure.
A. 0.9072 *
B. 0.4197
C. 0.2260
D. 0.2404

79. 2.5 liters of superheated steam at 25 bar and 400°C (v = 0.1252 m^3/kg) is expanded in an engine to a pressure of 0.1 bar (v_g = 14.674 m^3/kg , v_f = 0.0010102 m^3/kg) when its dryness fraction is 0.9. Find the final volume of the steam.
A. 163.74 liters
B. 263.74 liters *
C. 363.74 liters
D. 463.74 liters

80. A 1.5 kg of wet steam at a pressure of 5 bar (h_f = 640 kJ/kg, h_{fg} = 2109 kJ/kg) dryness 0.95 is blown into 70 liters of water of 12°C (h = 50.4 kJ/kg). Find the final enthalpy of the mixture.
A. 74.80 kJ/kg
B. 84.80 kJ/kg
C. 94.80 kJ/kg
D. 104.80 kJ/kg *

81. Wet saturated steam at 16 bar (h_f = 859 kJ/kg , h_{fg} = 1935 kJ/kg) reducing valve and is throttled to a pressure of 8 bar (h_f = 721 kJ/kg, h_{fg} = 2048 kJ/kg). Find the dryness fraction of the reduced pressure steam.
A. 0.8833
B. 0.7733
C. 0.9933 *
D. 0.6633

82. Calculate the higher heating value of liquid dodecane fuel. The chemical formula of Dodecane is $C_{12}H_{26}$.
A. 48,255 kJ/kg *
B. 55,641 kJ/kg
C. 60,221 kJ/kg
D. 35,245 kJ/kg

83. A 650 BHP diesel engine uses fuel oil of 28°API gravity, fuel consumption is 0.65 lb/BHP-hr. Cost of fuel is P 7.95 per liter. For continuous operation, determine the minimum volume of cubical day tank in cm^3, ambient temperature is 45°C.
A. 4,372,890 cm^3
B. 5,987,909 cm^3
C. 5,291,880 cm^3 *
D. 7,352,789 cm^3

84. A typical industrial fuel oil, $C_{16}H_{32}$ with 20% excess air by weight. Assuming complete oxidation of the fuel, calculate the actual air-fuel ratio by weight.
A. 17.56 kgair/kgfuel
B. 15.76 kgair/kgfuel
C. 16.75 kgair/kg fuel
D. 17.65 kgair/kgfuel *

85. Fuel oil in a day tank for use of an industrial boiler is tested with hydrometer. The hydrometer reading indicates a S.G. = 0.924 when the temperature of the oil in the tank is 35°C. Calculate the higher heating value of the fuel.
A. 43,852.13 kJ/kg *
B. 53,852.13 kJ/kg
C. 58,352.13 kJ/kg
D. 48,352.13 kJ/kg

86. A diesel electric plant supplies energy for Meralco. During a 24 hr period, the plant consumed 200 gallons of fuel at 28°C and produced 3930 kW-hr. Industrial fuel used is 28°API and was purchased at P 5.50 per liter at 15.6°C . What should the cost of fuel be produce one kw-hr?
A. P 1.05 *
B. P 1.10
C. P 1.069
D. P 1.00

87. A certain coal has the following ultimate analysis :
C = 70.5 % H = 4.5 % O_2 = 6 % N_2 = 1.0 %
S = 3.0% Ash = 11 % Moisture = 4%
A stoker fired boiler of 175,000 kg/hr steaming capacity uses this coal as fuel. Calculate the volume of air in m^3/hr with air at 60°F (15.6°F) and 14.7 psia (101.325 kPa) the coal is burned with 30% excess air. Boiler efficiency of 70% and factor of evaporation of 1.10.
A. 212,861.04 m^3/hr *
B. 221,861.04 m^3/hr
C. 218,261.04 m^3/kg
D. 281,261.04 m^3/kg

88. A diesel power plant consumed 1 m^3 of fuel with 30°API at 27°C in 24 hrs. Calculate the fuel rate in kg/hr.
A. 36.21 *
B. 26.25
C. 29.34
D. 39.42

89. A diesel power plant uses fuel with heating value of 43,000 kJ/kg. What is the density of the fuel at 25°C?
A. 840 kg/m^3
B. 873 kg/m^3
C. 970 kg/m^3 *
D. 940 kg/m^3

90. A fuel oil has the following contents: 85.5 % carbon, 11.9% hydrogen, 1.6% oxygen, and 1 % impurities. Calculate the percentage CO_2 in the flue gas for complete combustion.
A. 20.94 % *
B. 30.94 %
C. 35.5 %
D. 17.56 %

91. A water tube boiler has a capacity of 1000 kg/hr of steam. The factor of evaporation is 1.3, boiler rating is 200%, boiler efficiency is 65%, heating surface area is 0.91 m^2 per bo. Hp , and the heating value of fuel is 18,400 kCal /kg. The total coal available in the bunker is 50,000 kg. Determine the no. of hrs to consume the available fuel.
A. 853.36 hrs *
B. 706.57 hrs
C. 979.46 hrs
D. 100.75 hrs

92. Two boilers are operating steadily on 91,000 kg of coal contained in a bunker. One boiler is producing 1591 kg of steam per hour at 1.2 factor of evaporation and an efficiency of 65% and another boiler produced 1364 kg of steam per hour at 1.15 factor of evaporation and an efficiency of 60%. How many hrs will the coal in the bunker run the boilers if the heating value of coal is 7,590 kCal/kg ?
A. 230.80 hrs *
B. 280.54 hrs
C. 350.35 hrs
D. 300.54 hrs

93. The heating value of fuel supplied in a boiler is 40,000 kJ/kg. If the factor of evaporation is 1.10 and the actual specific evaporation is 10, what is the efficiency of the boiler ?
A. 62.07 % *
B. 53.08 %
C. 78.05 %
D. 54.97 %

94. A boiler contains 3.5 tons of water initially having 40 ppm dissolved solids and after 24 hrs the dissolved solids in the water is 2500 ppm. If the feed rate is 875 kg/hr, find the ppm of dissolved solids contained in the feed water.
A. 410 ppm *
B. 320 ppm
C. 390 ppm
D. 420 ppm

95. A travelling-grate stoker can burn bituminous coal with 10% moisture and 10 % ash at a rate of 500,000 BTU/hr-ft^2 . A boiler with a steam rating of 200,000 lb/hr will be fired with the above fuel having a high heat value of 12,200 BTU/lb. If the boiler efficiency is 80% , and if it takes 1000 BTU to evaporate and superheat one pound of feedwater to the desired temperature, find the hourly coal supply and grate area needed.
A. 20,500 lb, 500 ft^2 *
B. 26,400 lb, 700 ft^2
C. 28,200 lb, 400 ft^2
D. 22,600 lb, 200 ft^2

96. What is the rate of evaporation of a water tube boiler if the factor of evaporation is 1.10, percent rating of 200% and the heating surface area is 250 m^2 ?
A. 7,817.16 kg/hr *
B. 7,898.67 kg/hr
C. 6,789.45 kg/hr
D. 5,768.54 kg/hr

97. Steam is admitted to the cylinder of an engine in such a manner the average pressure is 120 psi. The diameter of the piston is 10 in. and the length of stroke is 12 in. What is the Hp of the engine when it is making 300 rpm ?
A. 171.5 Hp *
B. 175 Hp
C. 173.2 Hp
D. 174.4 Hp

98. Steam enters a turbine stage with an enthalpy of 3628 kJ/kg at 70 m/s and leaves the same stage with an enthalpy of 2846 kJ/kg and a velocity of 124 m/s. Calculate the power if there are 5 kg/s steam admitted at the turbine throttle ?
A. 4597.45 kW
B. 3976.55 kW
C. 3883.81 kW *
D. 1675.42 kW

99. Steam with an enthalpy of 800 kCal/kg enters a nozzle at a velocity of 80 m/s. Find the velocity of the steam at the exit of the nozzle if its enthalpy is reduced to 750 kCal/kg, assuming the nozzle is horizontal and disregarding heat losses. Take g = 9.81 m/s² and J constant = 427 kg m/kCal.
A. 452.37 m/s
B. 245.45 m/s
C. 651.92 m/s *
D. 427.54 m/s

100. Steam is expanded through a nozzle and the enthalpy drop per kg of steam from the initial pressure to the final pressure is 60 kJ. Neglecting friction, find the velocity of discharge and the exit area of the nozzle to pass 0.20 kg/s if the specific volume of the steam at exit is 1.5 m³/kg.
A. 346.4 m/s , 879 m²
B. 356.7 m/s , 278 m²
C. 765.6 m/s ,467 m²
D. 346.4 m/s, 866 m² *

101. A 6 MW steam turbine generator power plant has a full-load steam rate of 8 kg/kW-hr. Assuming that no-load steam consumption as 15% of full-load steam consumption, compute for the hourly steam consumption at 75% load, in kg/hr.
A. 37,800 kg/hr *
B. 38,700 kg/hr
C. 30,780 kg/hr
D. 30,870 kg/hr

102. A 4 kg air enters a turbine with enthalpy of 600 kJ and velocity of 250 m/s. The enthalpy at exit is 486 kJ and velocity of 170 m/s. What is the work developed if there is a heat loss of 10 kJ ?
A. 128.83 kJ
B. 171.2 kJ *
C. 80.2 kJ
D. 28.3 kJ

103. The feedwater to a boiler is 92% condensate and 8% make-up containing 270 ppm solids. What weight of solids enter the boiler per hour at 22,680 kg per hr steam evaporation.
A. 0.49 kg solids/hr *
B. 0.59 kg solids/hr
C. 0.39 kgsolids/hr
D. 0.69 kgsolids/hr

104. The 1370 diameter steam drum on a boiler is 2440 mm long has a 250 mm gauge glass at mid-drum level. Find the maximum steam generation that could be cared for by a blowdown of half a water gauge each 8 hr. shift. Pressure, 17.5 kg/cm² gage. S_f = 150 PPM, S_b = 2000 PPM.
A. 450.59 kg/hr
B. 550.59 kg/hr *
C. 650.59 kg/hr
D. 750.59 kg/hr

105. Estimate discharge rate (L/min) and maximum suction lift of a 95 mm x 127 mm x 152 mm duplex, direct-acting steam pump. e_v = 0.90 sea level.
A. 187.90 L/min
B. 287.90 L/min
C. 487.90 L/min.
D. 387.90 L/min. *

106. Calculate drive horsepower for pumping 1703 L/min cold water to a tank suction at 127 mm Hg vacuum, delivery at 5.3 kg/cm² ga., both measured close to pump, e_p = 0.65.
A. 31.42 HP *
B. 20.42 HP
C. 35.42 HP
D. 23.02 HP

107. Given a horizontal conveyor, 46 m centers, 175 pounds per hr capacity of handling bituminous coal at 0.5 m/s with 800 kg per m³. Other data as follows:

Flight width and depth	610 mm x 200 mm
Quantity of material	0.108 m³/m
Coefficient of friction elements	0.10
Material Coefficient of friction	0.59

Assume an engineering-type chain with sleeve bearing rollers weighing with flights, 89.3 kg/m. Calculate the chain pull in kg.
A. 2180.33
B. 4550.10
C. 1555.36
D. 3166.46 *

108. Find the length of a suspension bunker to contain 181 tons of coal without surcharge; width, 4.6 m; depth 4.3 m. The level capacity of a suspension bunker is 5/8 wdL where : w = width , d = depth and L = length. Density of coal, 800 kg/m³.
A. 18.30 m *
B. 13.80 m
C. 17.61 m
D. 12.61 m

109. The individual buckets of a vertical elevator carry 3.6 kg coal and are spaced 30.5 cm apart on the chain. Sprocket wheels 61 cm diameter, chain speed 79.2 m/min. Height between sprockets, 9.1 m. Drive: 1750 – rpm motor through sprockets and steel roller chain. What is the motor horsepower required to drive the conveyor drive shaft?
A. 2 Hp
B. 4 Hp
C. 5 Hp
D. 3 Hp

110. A 305 mm x 457 mm four stroke single acting diesel engine is rated at 150 kW at 260 rpm. Fuel consumption at rated load is 0.26 kg/kW-hr with a heating value of 43,912 kJ/kg. Calculate the brake thermal efficiency.
A. 31.63 % *
B. 41.63 %
C. 21.63 %
D. 35.63 %

111. A 500 kW diesel has a heat rate of 12,000 kJ/kw-hr. The compression ratio is 16:1, cut of ratio of 2.3. Assume k = 1.32. Calculate the engine efficiency based on the output of 500 kW.
A. 57.77 % *
B. 57.78 %
C. 47.77 %
D. 37.67 %

112. The brake thermal efficiency of a 1 MW diesel electric plant is 36 %. Find the heat generated by fuel in kW if the generator efficiency is 89 %.
A. 3,121.10 Kw *
B. 3,528.64 kW
C. 4,121.10 kW
D. 4,528.64 kW

113. Air enters the combustion chamber of a gas turbine unit at 550 kPa, 227°C and 43 m/s. The products of combustion leave the combustor at 517 kPa, 1007°C and 140 m/s. Liquid fuel enters with a heating value of 43,000 kJ/kg. The combustor efficiency is 95 % . What is the air-fuel ratio ? Note: Properties of air :

T(K)	h(kJ/kg)
500	503.02
1280	1372.25

A. 47.39
B. 32.25
C. 56.93
D. 44.95 *

114. Air is drawn into a gas turbine working on the constant pressure cycle at 1 bar 21°C and compressed to 5.7 bar. The temperature at the end of heat supply is 680°C. Taking expansion and compression to be adiabatic where C_v = 0.718 kJ/kg-K, C_p = 1.055 kJ/kg-K, calculate the heat energy supplied per kg at constant pressure.
A. 472 kJ/kg *
B. 389 kJ/kg
C. 501 kJ/kg
D. 489 kJ/kg

115. There are required 2200 kW net from a gas turbine unit for pumping of crude oil. Air enters the compressor section at 100 kPa, 280 K, the pressure ratio r_p = 10. The turbine section receives the hot gases at 1,100 K. Assume the closed Brayton cycle and determine the required air flow.
A. 7.91 kg/s
B. 7.16 kg/s
C. 8.11 kg/s *
D. 8.91 kg/s

116. In an air-standard Bryton cycle, the compressor receives air at 101.325 kPa, 21°C and it leaves at 600 kPa at the rate of 4 kg/s. Determine the turbine work if the temperature of the air entering the turbine is 1000°C.
A. 3000 kW
B. 2701 kW
C. 2028 kW *
D. 3500 kW

117. The net power output of an air-standard Brayton cycle is 200 kW. Air enters the compressor at 32°C and leaves the high-temperature heat exchanger at 800°C. What is the mass flow rate of air if it leaves the turbine at 350°C ?
A. 0.57 kg/s
B. 0.67 kg/s
C. 0.77 kg/s
D. 0.87 kg/s *

118. Kerosene is the fuel of a gas turbine plant : fuel – air ratio, m_f = 0.012, T_3 = 972K , pressure ratio, r_p = 4.5, exhaust to atmosphere. Find the available energy in KJ per kg air flow. Assume k = 1.34 and C_p = 1.13.
A. 352.64 kJ/kg *
B. 452.64 kJ/kg
C 252.64 kJ/kg
D 552.64 kJ/kg

119. An ideal gas turbine operates with a pressure ratio of 10 and the energy input in the high temperature heat exchanger is 300 kW. Calculate the air flow rate for a temperature limits of 30°C and 1200°C.
A. 0.25 kg/s
B. 0.34 kg/s *
C. 0.41 kg/s
D. 0.51 kg/s

120. In an air-standard Brayton cycle the inlet temperature and pressure are 20°C and 101.325 kPa. The turbine inlet conditions are 1200 kPa and 900°C. Determine the air flow rate if the turbine produces 12 MW.
A. 21.41 kg/s
B. 20.20 kg/s *
C. 19.25 kg/s
D. 18.10 kg/s

121. A gas turbine power plant operating on the Brayton cycle delivers 15 MW to a standby electric generator. What is the mass flow rate and the volume flow rate of air if the minimum and maximum pressures are 100 kPa and 500 kPa respectively, and temperatures of 20°C and 1000°C.
A. 31.97 kg/s , 26.88 m³/s
B. 36.98 kg/s , 28.99 m³/s
*C. 41.97 kg/s , 26.88 m³/s
D. 46.98 kg/s , 28.99 m³/s

122. In a hydraulic plant the difference in elevation between the surface of the water at intake and the tailrace is 650 ft when the flow is 90 cfs, the friction loss in the penstock is 65 ft and the head utilized by the turbine is 500 ft. The mechanical friction in the turbine is 110 Hp, and the leakage loss is 4 cfs. Find the hydraulic efficiency.
A. 87.45 %
B. 84.57 %
C. 85.47 % *
D. 78.54 %

123. A pelton wheel runs at a constant speed under a head of 650 ft. The cross-sectional area of the jet is 0.50 ft² and the nozzle friction loss is to be neglected. Suppose the needle of the nozzle is to be adjusted as to reduce the area of the jet from 0.50 ft² to 0.20 ft² . Under these conditions the efficiency of the wheel is known to be 70% . Find the power output of the wheel.
A. 2112.34 Hp *
C. 3017.62 Hp

B. 2506.34 Hp D. 3462.74 Hp

124. A hydro-electric power plant consumes 60,000,000 kW-hr per year . What is the net head if the expected flow is 1500 m^3/min and over-all efficiency is 63%.
A. 34.34 m
B. 43.43 m C. 44.33 m *
D. 33.44 m

125. A pelton type turbine has a gross head of 40 m and a friction head loss of 6 m. What is the penstock diameter if the penstock length is 90 m and the coefficient of friction head loss is 0.001 (Morse).
A. 2040 mm *
B. 3120 mm C . 2440 mm
D. 2320 mm

126. The water velocity of a 5 m x 1 m channel is 6 m/s. What is the annual energy produced if the net head is 120 m and the over-all efficiency is 80%.
A. 494,247,258 kw-hrs C. 247,494,528 kW-hrs *
B. 247,497,582 kW-hrs D. 472,497,582 kW-hrs

127. A hydro-electric impulse turbine is directly coupled to a 24 pole, 60 Hz alternator. It has a specific speed of 60 rpm and develops 3000 Hp. What is the required diameter assuming a peripheral speed ratio of 0.45.
A. 0.661 m *
B. 0.552 m C 0.443 m
D. 0.775 m

128. In a hydroelectric power plant the tailwater elevation is at 500 m. What is the head water elevation if the net head is 30 m and the head loss is 5% of the gross head ?
A. 785.25 m
B. 582.57 m C. 528.57 m *
D. 758.25 m

129. The tailwater and the headwater of a hydro-electric plant are 150 m and 200 m respectively. What is the water power if the flow is 15 m^3/s and a head loss of 10% of the gross head ?
A. 6,621.75 Kw * C. 5,621.76 kW
B. 7,621.65 kW D. 4,621.56 kW

130. In a hydro-electric plant, water flows at 10 m/s in a penstock of 1 m^2 cross-sectional area. If the net head of the plant is 30 m and the turbine efficiency is 85%, what is the turbine output?
A. 2,501.55 kW * C. 3,626.34 kW
B. 2,100.21 kW D. 3,124.65 kW

131. A nuclear power plant is to have a capacity of 500 MW-electrical. How many pounds of U^{235} are needed to operate the plant continuously for 6 years if the plant capacity factor is 75% and thermal efficiency is 35%.
A. 5179.05 * C. 6426.25
B. 5375.01 D. 6778.64

132. A 600 MWe PWR nuclear plant uses 4% enriched Uranium fuel has a thermal efficiency of 36%. The burn up allowed of the fissionable portion of the fuel is 20%. Calculate how many metric tons of natural Uranium is placed in the reactor vessel for one year continuous operation?
A. 69.34 C. 88.56
B. 79.35 * D. 56.77

133. A 75 MW power plant has an average load of 35,000 kW and a load factor of 65%. Find the reserve over peak.
A. 21.15 MW * C. 25.38 MW
B. 23.41 MW D. 18.75 MW

134. A power plant is said to have/had a use factor of 48.5% and a capacity factor of 42.4%. How many hrs. did it operate during the year ?
A. 6,600.32 hrs C. 8,600.32 hrs
B. 7,658.23 hrs * D. 5,658.23 hrs

135. A 50,000 kW steam plant delivers an annual output of 238,000,000 kW-hr with a peak load of 42,860 kW. What is the annual load factor and capacity factor?
A. 0.634, 0.534
B. 0.643, 0.534 C. 0.634, 0.543 *
D. 0.643, 0.534

136. Calculate the use factor of a power plant if the capacity factor is 35% and it operates 8000 hrs during the year?
A. 38.325 % * C. 35.823 %
B. 33.825 % D. 32.538 %

137. Calculate the use factor of a power plant if the capacity factor is 35% and it operates 8000 hrs during the year?
A. 38.325 % * C. 35.823 %
B. 33.825 % D. 32.538 %

138. If the air required for combustion is 20 kg per kg of coal and the boiler uses 3000 kg of coal per hr, determine the mass of gas entering the chimney. Assume an ash loss of 15%.
A. 40,644 kg/hr C. 62,550 kg/hr *
B. 70,200 kg/hr D. 50,500 kg/hr

139. A 15 kg gas enters a chimney at 10 m/s. If the temperature and pressure of a gas are 26°C and 100 kPa respectively, what is the diameter of the chimney. Use R = 0.287 kJ/kg-K.
A. 1.57 m C. 2.22 m
B. 2.65 m D. 1.28 m *

140. A 39.5 m high chimney of radial brick masonry is described by the following top and bottom dimensions. D_2 = 1.9 m, d_2 = 1.5 m, D_1 = 3.2 m, d_1 = 2.3 m. Determine the moment due to wind load.
A. 172,051 kg-m C. 150,160 kg-m
B. 160,388 kg-m D. 182,030 kg-m *

141. A two-stage air compressor at 90 kPa and 20°C discharges at 700 kPa. Find the polytropic exponent n if the intercooler intake temperature is 100°C.
A. 1.29 * C. 1.4
B. 1.33 D. 1.25

142. A two-stage compressor receives 0.35 kg/s of air at 100 kPa and 269 K and delivers it at 5000 kPa. Find the heat transferred in the intercooler.
A. 70.49 Kw * C. 90.49 kW
B. 80.49 kW D. 100.49 kW

143. A two-stage compressor receives 0.35 kg/s of air at 100 kPa and 269 K and delivers it at 5000 kPa. Find the heat transferred in the intercooler.
A. 70.49 KW * C. 90.49 kW
B. 80.49 kW D. 100.49 kW

144. A centrifugal pump discharged 20 L/s against a head of 17 m when the speed is 1500 rpm. The diameter of the impeller was 30 cm and the brake horsepower was 6.0. A geometrically similar pump 40 cm in diameter is to run at 1750 rpm. Assuming equal efficiencies, what brake horsepower is required?
A. 51.55 HP C. 40.15 HP *
B. 50.15 HP D. 45.15 HP

145. A condensate pump at sea level take water from a surface condenser where the vacuum is 15 in. of mercury. The friction and turbulence in the piping in the condenser hot well and the pump suction flange is assumed to be 6.5 ft. If the condensate pump to be installed has a required head of 9 ft, what would be the minimum height of water level in the hot well that must be maintained above the centerline of the pump to avoid cavitation?
A. 2.5 ft C. 18 ft
B. 15.5 ft * D. 5.5 ft

146. A pump delivers 20 cfm of water having a density of 62 lb/ft^3. The suction and discharge gage reads 5 in. Hg vacuum and 30 psi respectively. The discharge gage is 5 ft above the suction gage. If pump efficiency is 70%, what is the motor power ?
A. 5.31 Hp C. 4.31 Hp *
B. 3.31 Hp D. 6.31 Hp

147. Calculate the air power of a fan that delivers 1200 m^3/min of air through a 1 m by 1.5 m outlet. Static pressure is 120 mm WG and density of air is 1.18.
A. 20.45 kW C. 30.45 kW
B. 25.64 kW * D. 35.64 Kw

148. The fan has a total head of 190 m and a static pressure of 20 cm WG. If the air density is 1.2 kg/m^3, what is the velocity of air flowing?
A. 16.21 m/s C. 16.66 m/s
B. 17.21 m/s D. 17.766 m/s *

149. A tank contains 3 ft^3 of 120 psig air at 80°F. How many tires of volume 1.2 ft^3 can be inflated to 28 psig at 80°F?
A. 5 complete tires * C. 7 complete tires
B. 10 completer tires D. 3 complete tires

150. What is the root-mean-squared velocity of oxygen molecules at a temperature of 70°F ?
A. 571 ft/s C. 2310 ft/s
B. 1570.66 ft/s * D. 3852 ft/s

151. What is the rise in temperature of water dropping over a 200 ft waterfall and settling in a basin below ? Neglect all friction and assume initial velocity is negligible.
A. – 0.543 deg. F C. – 0.376 deg. F
B. – 0.257 deg. F * D. – 0.543 deg. F

152. The turbine of a jet engine operates adiabatically and receives a steady flow of gases at 114 psia, 1340°F and 540 ft/s. It discharges at 30.6 psia, 820°F 1000 ft/s. Find the work output per pound of gas.
A. 123.7 Bt u/hr *
B. 321.7 Btu/hr C. 432.7 Btu/hr
D. 245.7 Btu/hr

153. One kilogram of air 1.2 kg/cm^2 at 30°C is compressed according to the law of PV where : C = 1.36 until its volume 0.5 m^3 if its is compressed isothermally . What will be the percent saving work ?
A. 5.6 %
B. 8.7 % C. 6.6 % *
D. 8.2 %

154. An electron strikes the screen of the cathode ray tube with a velocity of 10 to the 9th power cm/s. Compute its kinetic energy in ERGS. The mass of an electron is 9 x 10^{-31} kg ?
A. 1.5 x 10-10 ERG C. 3.5 x 10-10 ERG
B. 9.5 x 10-10 ERG D. 4.5 x 10-10 ERG *

155. A 0.064 kg of octane vapor (MW = 114) is mixed with 0.91 kg of air (MW = 29.0) in the manifold is 86.1 kPa, and the temperature is 290 K. Assume octane behaves ideally, what is the total volume of this mixture?
A. 0.895 cu.m. *
B. 0.987 cu. m
C. 0.565 cu. m.
D. 0.654 cu.m.

156. Find the amount of electrical energy expended raising the temperature of 45 liters of water by 75°C. Assume the efficiency of the heating equipment to be 90% ?
A. 5.35 kW-hr
B. 3.46 kW-hr *
C. 0.565 kW-hr.
D. 0.654 kW-hr.

157. How long could a 2000 hp motor be operated on the heat energy liberated by 1 mi.^{3} of ocean water when the temperature of the water is lowered by 1°C and if all these heat were converted to mechanical energy?
A. 371.56 *
B. 243.55
C. 384.76 yrs
D. 376.57 yrs

158. A jet of water is discharge through a 1– inch diameter orifice under constant head of 2.1 ft the total discharge is 228 lbm in 90 seconds. The jet is observed to pass through a point 2 ft downward and 4 ft away form vena contracta. Coefficient of contraction.
A. 0.786
B. 0.658 *
C. 0.567
D. 0.345

159. A jet of water is discharge through a 1– inch diameter orifice under constant head of 2.1 ft the total discharge is 228 lbm in 90 seconds. The jet is observed to pass through a point 2 ft downward and 4 ft away form vena contracta. Coefficient of velocity.
A. 0.976 *
B. 0.758
C. 0.567
D. 0.845

160. The density of Helium is 0.178 kg/m^3 at STP. What is the density at 25°C and 96 kPa?
A. 0.159 *
B. 0.358
C. 0.267
D. 0.545

161. A gas has a density of 0.094 lb/ft^3 at 100°F and 2 atm. What pressure is needed to change the density to 0.270 lb/ft^3 at 250°F ?
A. 7.28 atm *
B. 6.32 atm
C. 3.45 atm
D. 5.25 atm

162. If atmospheric air 14.7 psia and 60°F at sea level, what is the pressure at 12000 ft altitude if air is incompressible.Note: @ 60°F ; the density of air is 0.0763 lbm/ft^3 ; P_1 = 14.7 psia
A. 5.42 psia *
B. 5.34 psia
C. 6.72 psia
D. 9.32 psia

163. To what height will 68°F ethyl alcohol rise in a 0.005 inch internal diameter glass capillary tube? The density of alcohol is 49 lbm/ft^3.
where: $\beta = 0°$ = contact angle $\sigma = 0.00156$ lbf/ft @ 68°F
A. 0.3056 ft *
B. 0.4584 ft
C. 0.5434 ft
D. 0.2435 ft

164 What is the velocity of sound in 150°F (66°C) air at a standard pressure? Note: density of air @ 150°F is 0.064 lbm/ft^3
A. 1215 ft/s *
B. 3245 ft/s
C. 2345 ft/s
D. 4321 ft/s

165. Ideal Oxygen is throttled at 140°F from 10 atm to 5 atm. What is the temperature change ?
A. 0 *
B. negative
C. infinity
D. 1

166. A cold tire contains 1000 in.^{3} of air at 24 psia and 32°F. What pressure in the tire is needed if the temperature and volume are increased to 35°F and 1020 in.^{3} respectively ?
A. 23.57 psia *
B. 32.45 psia
C. 43.54 psia
D. 34.57 psia

167. Determine the specific gravity of carbon dioxide gas (molecular weight = 44) at 150°F (66°C) and 20 psia (138 kPa).
A. 1.67 *
B. 1.45
C. 1.87
D. 1.30

168. An empty polyethylene telemetry balloon and payload have a mass of 500 lb_m. The balloon is charged with helium when the atmospheric conditions are 60°F and 14.8 psia. The specific gas constant of helium is 386.3 ft-lbf / lb_m°R. What is the volume of helium is required ?
A. 7544 ft^3 *
B. 6754 ft^3
C. 7455 ft^3
D. 6456 ft^3

169. A pipe of internal diameter 6 units carries water with a depth of 3 unit under in influence of gravity. Calculate the Hydraulic radius.
A. 1.12 *
B. 1.32
C. 2.31
D. 1.01

170. Water (ρ = 1000 kg/m^3, E = 2 x 10^9 Pa) is flowing at 4 m/s through a long length of 4 –in schedule – 40 steel pipe (D = 0.102 m , t = 0.0062 m, E = 2 x 10^{11}Pa) when a valve suddenly closes completely. What is the theoretical increase in pressure ?
A. ΔP = 2.23 x 10^6 Pa
B. ΔP = 1.23 x 10^6 Pa
C. ΔP = 0.23 x 10^6 Pa
D. ΔP = 5.23 x 10^6 Pa *

171. A pump adds 550 feet of pressure head to 100 lbm/s of water . Compute the hydraulic power in horsepower?
A. 100 *
B. 150
C. 200
D. 300

172. A pump driven by an electrical motor moves 25 gal/min of water from reservoir A to reservoir B, lifting the water a total head of 245 feet. The efficiencies of the pump and motor are 64% and 84% respectively. What is the size of motor required ?
A. 2. 42 Hp *
B. 3.24 Hp
C. 1.24 Hp
D. 2.34 Hp

173. A cetrifugal pump powered by a direct-drive induction motor is needed to discharge 150 gal/min against a 300-ft total head when turning at the fully loaded speed of 3500 rpm. What type of pump must be selected ?
A. Reciprocating pump
B. Radial vane pump *
C. screw pump
D. none of these

174. A pump is operating at 1770 rpm delivers 500 gal/min against a total head of 200 feet. Changes in the piping system have increased to the total head to 375 feet. At what rpm should this pump be operated to achieve this new head at the same efficiency ?
A. 2424 rpm *
B. 1424 rpm
C. 3225 rpm
D. 2327 rpm

175. A 6" pump operating at 1770 rpm discharges 1500 rpm discharges 1500 gpm of cold water (S.G. = 1.0) against an 80-foot head at 85% efficiency. A homologous 8" pump is operating at 1170 rpm is being considered as a replacement. What capacity of the total head can be expected from the new pump ?
A. 2350.3 gpm *
B. 4325.3 gpm
C. 3486.5 gpm
D. 3256.4 gpm

176. A 6" pump operating at 1770 rpm discharges 1500 rpm discharges 1500 gpm of cold water (S.G. = 1.0) against an 80-foot head at 85% efficiency. A homologous 8" pump is operating at 1170 rpm is being considered as a replacement. what is would be the new horsepower requirement ?
A. 43.3 Hp *
B. 34.6 Hp
C. 12.4 Hp
D. 54.3 Hp

177. Determine the hydraulic the diameter and the hydraulic radius for the open trapezoidal channel whose above and bottom lengths are 7 and 5 units respectively. The depth of the water is 3 units.
A. 13.4
B. 1.59 *
C. 3.24
D. 5.3

178. Water is pumped up a hillside into a reservoir. The pumped discharges water at the rate of 6 ft/s and pressure of 150 psig. Disregarding friction, what is the maximum elevation (above the centerline of pump's discharge) of the reservoir's water surface ?
A. 346.7 ft *
B. 546.7 ft
C. 246.7 ft
D. 146.7 ft

179. Water at 60°F has a specific gravity of 0.999 gm/cm^3 and a kinematic viscosity of 1.12 centistoke (cs) . What is the absolute viscosity in lbf – s / ft^2 ?
A. 2.34 x 10^{-5} *
B. 1.34 x 10^{-5}
C. 3.34 x 10^{-5}
D. 5.34 x 10^{-5}

180. A steam engine operating between a boiler temperature of 220 deg. C and a condenser temperature of 35 deg.C delivers 8 Hp. If its efficiency is 30 percent of the for a Carnot engine operating between this temperature limits, how many calories are absorbed each second by the boiler ?
A. 12.7 kCal/s *
B. 11.34 kCal/s
C. 10.56 kCal/s
D. 9.57 kCal/s

181. How many kilograms of water at 0 deg. C can a freezer with a coefficient of performance 5 make into ice cubes at 0 deg. C with a work input of 3.6 MJ (one kilowatt-hour) ?
A. 24 kg
B. 34 kg
C. 54 kg *
D. 15 kg

182. What is the change in entropy of 2 kg water molecules when transformed at constant pressure of 1 atmosphere from water at 100 deg. C to steam at the same temperature ?
A. 12.12 kJ/K *
B. 10.43 kJ/K
C. 9.45 kJ/K
D. 10.45 kJ/K

183. A copper can of negligible heat capacity contains 1 kg of water just above the freezing point. A similar can contains 1 kg of water just below the boiling point. Two cans are brought to into thermal contact . Find the change in entropy of the system ?
A. 100 J *
B. 200 J
C. 300 J
D. 400 J

184. In a gaseous mixture of 20 deg. C the partial pressures of the components are as follows: Hydrogen , 200 mmHg; Carbon dioxide, 150 mm Hg, methane, 320 mmHg; ethelyne, 105 mmHg. What is the mass fraction of hydrogen (m(H_2) = 2 , m(CO_2) = 44, m(meth) = 16 and m(eth) = 30 kg/mol) ?
A. 0.026 *
B. 0.056
C. 0.076
D. 0.016

185. Assume the total heat of vaporization (per gram) of water can be used to supply the energy needed to tear 1 g of water molecules apart from each other. How much energy is needed per molecule for this purpose?
A. 6.74×10^{-20} J *
B. 1.74×10^{-20} J
C. 3.74×10^{-20} J
D. 2.74×10^{-20} J

186. Assume the total heat of vaporization (per gram) of water can be used to supply the energy needed to tear 1 g of water molecules apart from each other. What is the ratio of energy needed per molecule to kT where $k = 1.38 \times 10^{-23}$ J/K ?
A. 11.3
B. 12.5
C. 13.1 *
D. 12.3

187. Cool water at 9 deg. C enters hot-water heater from which warm water at a room temperature of 80 deg.C is drawn at an average rate of 300 g/min. How much average electric power does the heater consume in order to provide hot water at this rate ?
A. 4.18 kW *
B. 2.35 kW
C. 3.31 kW
D. 5.14 kW

188. A hose shoots water straight up a distance of 2.5 m. The end opening on the hose has an area of 0.075 cm^2 . How much water comes out in 1 min ?
A. 34.18 li
B. 22.35 li
C. 31.5 li *
D. 5.14 li

189. The surface of household radiator has an emissivity of 0.55 and an area of 1.5 m^2 At what rate is the radiation absorbed emitted by the radiator when its temperature is 50 deg. C
A. 308 W
B. 509 W *
C. 108 W
D. 409 W

190. It is required to pump water at 100 gal per min from a large reservoir to the surface of another reservoir 400 feet higher. What is the horsepower of the motor to drive the pump, if the efficiency of the pump is 70% ?
A. 14.44 Hp *
B. 15.55 Hp
C. 12.54 Hp
D. 10.54 Hp

191. Compute is the percent rating of a water tube boiler if the heating surface area is 500 m^2 and the developed boiler horsepower is 750 ?
A. 136.5 % *
B. 124.5 %
C. 138.7 %
D. 154.6 %

192. A waste heat recovery boiler produces 4.8 MPa (dry saturated) steam from 104°C feed water. The boiler receives energy from 7 kg/s of 954°C dry air. After passing through the waste heat boiler, the temperature of the air has been reduced to 343°C. Compute the volume flow rate of the steam in kg produced per second ? Note: At 4.8 MPa dry and saturated, h = 2796.0 kJ/kg.
A. 1.81 kg *
B. 1.92 kg
C. 2.21 kg
D. 1.46 kg

193. What is the power which a 3.5 MW natural gas engine can developed at an altitude of 1981.2 m assuming that the pressure change alone.
A. 2.957 MW *
B. 3.247 MW
C. 2.521 MW
D. 4.466 MW

194. In a gaseous mixture of 20 deg. C the partial pressures of the components are as follows: Hydrogen , 200 mmHg; Carbon dioxide, 150 mm Hg, methane, 320 mmHg; ethelyne, 105 mmHg. What is the total pressure of the mixture ?
A. 755 mm Hg *
B. 255 mm Hg
C. 345 mm Hg
D. 800 mm Hg

195. A four stroke, direct injection diesel engine of 4 in. bore x 4.5 in. stroke develops 45 Hp at full load and 8 Hp when running at idling load. Engine speed is 2,200 rpm. Compute the mechanical efficiency.
A. 56.52 %
B. 86.71 % *
C. 79.21%
D. 88.46 %

196. The ultimate analysis of coal is given below:
C = 68.5 % S = 1.5 % Ash = 12.0 %
H = 2.5 % O = 3.5 %
What is the higher heating value of coal.
A. 26,280.63 kJ/kg *
B. 16,250.63 kJ/kg
C. 41,380.53 kJ/kg
D. 56,298.32 kJ/kg

197. In a boiler design, it is desirable to have the flue gas exit temperature above the dewpoint. What is the dew point temperature of the flue gas produced by combustion having the gravimetric analysis of :
N_2 = 71.84 % O_2 = 3.61 %
CO_2 = 20.35 % H_2O = 4.20 %
Assume that air infiltration and leakage are negligible.
A. 45 deg C
B. 40 deg C
C. 39 deg C *
D. 24 deg C

198. Find the effective head of a reaction turbine that develops 500 BHP where flow through the turbine is 50 cfs. Water enters at 20 fps with a 100 ft pressure head. The elevation of the turbine above the tailwater level is 8 ft.
A. 136.52 ft
B. 131.71 ft
C. 114.2 ft *
D. 102.4 ft

199. Water (ρ = 62.4 lbm/ft^3) is flowing through a pipe. A pitot-static gage registers 3.0 inches of mercury. What is the velocity of the water in the pipe?
A. 14.24 ft/s *
B. 13.42 ft/s
C. 11.42 ft/s
D. 10.24 ft/s

200. A refrigeration system produces 20 kg/hr of ice from water at 20 deg. C. Find the tonnage of the unit.
A. 0.66 *
B. 0.55
C. 0.77
D. 0.88

...End...