1. An adiabatic tank containing air is used to power an air turbine during times of peak power demand. The tank has a volume of 500 m3 and contains air at 1000 kPa and 500Kpa. Determine the mass remaining when the pressure reaches 100 kPa. $T_1 = 500K$

A. 276.37 kg
B. 672.73 kg
C. 772.73 kg
D. 227.73 kg

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$\frac{T_2}{500K} = \left(\frac{100}{1000}\right)^{\frac{1.4-1}{1.4}}$$

$$T_2 = 258.97\,K$$

$$P_2 V_2 = m_2 R T_2$$

$$(100\,kPa)(500\,m^3) = m_2\left(0.287\,\frac{kJ}{kg\text{-}K}\right)(258.97K)$$

$$\boxed{m_2 = 672.73\,kg}$$

2. To complete one cycle, two stroke engine performs_____.

A. suction and discharge stroke
B. power and exhaust stroke
C. suction and exhaust stroke
D. compression & power stroke

3. A common filter material used for brazing is composed of:

A. 95/5 tin-antimony
B. 50/50 tin-lead
C. Cast steel
D. 15 % to 60 % silver

4. A spherical ball with a ~~diameter~~ radius of 5 centimeter and whose surface is maintained at a temperature of 70°C is suspended in the middle of a room at 20°C. If the convection heat transfer coefficient is 15 W/m2-C and the emissivity of the surface is 0.8, what is the total heat transfer from the ball.

A. 23.56 watts
B. 9.22 watts
C. 43.45 watts
D. 32.77 watts

$$Q_{RAD} = \varepsilon \sigma A_s (T_1^4 - T_2^4)$$

$A_s = \pi D^2$

$$= (0.8)\left(5.67\times10^{-8}\ \frac{W}{m^2\text{-}K^4}\right)\left(\pi\left(\frac{5\times2}{100}\right)^2 m^2\right)\left((70+273)^4 - (20+273)^4\right) K^4$$

$$= 9.22\ W$$

$$Q_{CONV} = h A_s \Delta T = \left(15\ \frac{W}{m^2\text{-}°C}\right)\left(\pi\left(\frac{5\times2}{100}\right)^2 m^2\right)\left((70-20)\right)°C$$

$$= 23.56\ W$$

$$Q_T = Q_{RAD} + Q_{CONV} = 9.22 + 23.56 = \boxed{32.77\ W}$$

5. Typical compression ratio of Otto cycle is

A. 6
B. 10
C. 8
D. 12

6. Is the ratio of the mass of water vapor in air and the mass of air if it is saturated is called:

A. Relative humidity
B. vapor ratio
C. mass ratio
D. humidity ratio

7. A two-pass surface condenser is to be designed using overall heat transfer coefficient of 480 Btu/°F-ft2 of outside copper tube surface. The copper 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.

A. 424.8 in
B. 20.4 in
C. 244.8 in
D. 40.2 in

$1{,}000{,}000\ \frac{lb}{hr}$

TOTAL LENGTH OF TUBES PER NUMBER OF TUBES = ?

$L = \frac{L_T}{n_T} / 2$

$m_w = (\rho A V)\, n_T$ → $\frac{\pi}{4} D^2$

$Q_{WATER} = Q_{STEAM}$

$m_w c \Delta T = m_s (h_1 - h_2)$

$m_w \left(1 \frac{BTU}{lb\text{-}°R}\right)(95-85)°R = 1{,}000{,}000 \frac{lb}{hr} \left(1090 - 69.72\right) \frac{BTU}{lb}$

$m_w = 102{,}028{,}000\ lb/hr$

$102{,}028{,}000 \frac{lb}{hr} = \left(62.4 \frac{lb}{ft^3}\right)\left(\frac{\pi}{4}\left(\frac{7}{8}\ in \times \frac{1\ ft}{12\ in}\right)^2\right)\left(6 \frac{ft}{s} \times \frac{3600\ s}{hr}\right) n_T$

$n_T = 18{,}127.48 \approx 18{,}200$ TUBES //

$L_T = ?$ → $\pi D L_T$

$Q_{STEAM} = U A_s (LMTD)$

$m_s (h_1 - h_2) = U (\pi D L_T)(LMTD)$

$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = \frac{16.7 - 6.7}{\ln\left(\frac{16.7}{6.7}\right)} = 10.95$

$(1{,}000{,}000)(1090 - 69.72) = 480(\pi \times \frac{1}{12} ft \times L_T)(10.95)$

$L_T = 741{,}473\ ft$

$\approx 742{,}000\ ft$ //

$L = \frac{742{,}000}{18{,}200} / 2$

$= 20.4\ ft \times \frac{12\ in}{ft}$

$= 244.8\ in$

101.7 → 95 → 85 → 101.7

$\Delta T_1 = 101.7 - 85 = 16.7$

$\Delta T_2 = 101.7 - 95 = 6.7$

8. The metering device _____.

A. Cycles the compressor
B. Stores refrigerant
C. Controls subcooling
D. Meters refrigerant

9. The hands feel painfully cold when the skin temperature reaches.

A. 14°C
B. 10°C
C. 8°C
D. 12°C

10. A precision and electronic barometer is used to measure an airplane's altitude by comparing the barometric pressure at a given flying altitude to that on the ground. What will be the airplane's altitude if the Captain's pilot measures the barometric pressure at 700 mm-Hg, the ground says it is at 758 mm-Hg, and the average air density is 1.19 kg/m3. g = 9.8 m/s2.

A. 889 m
B. 535 m
C. 980 m
D. 663 m

$$P_1 - P_2 = \rho g h$$

$$(758 - 700)\,\text{mm-Hg} \times \frac{101{,}325\ \text{N/m}^2}{760\ \text{mm-Hg}} = \left(1.19\ \frac{\text{kg}}{\text{m}^3}\right)\left(9.8\ \frac{\text{m}}{\text{s}^2}\right) h \quad (\text{N})$$

$$\boxed{h = 663\ \text{m}}$$

11. The total heat of the air is a function of

A. DB temperature
B. WB depression
C. DP temperature
D. WB temperature

12. In a refrigeration system, which of the four(4) is not a type of a water-cooled condenser?

A. Shell and tube
B. Shell and coil
C. Double tube
D. Double shell

13. A 22.7kg/s flow of air enters a preheater at a temperature of 28oC and leaves at a temperature of 150°C; 23.7kg/s of exhaust gases, cp=1.09kJ/kg-K, and enters at a temperature of 315oC. The overall coefficient of heat transfer is 710 W/m2-C. Calculate the surface area for counterflow.

A. 22.82m2
B. 27.49m2
C. 32.54m2
D. 28.77m2

$m_A = 22.7$ kg/s
$m_g = 23.7$ kg/s

$Q_A = Q_G$

$m_A C_p (T_{A_2} - T_{A_1}) = m_{GA} C_{pG} (T_{G_1} - T_{G_2})$

$(22.7)(1.005)(150 - 28) = (23.7)(1.09)(315 - T_{G_2})$

$T_{G_2} = 207.3°C$

$Q_G = h A_s (LMTD)$

$(23.7\ \frac{kg}{s})(1.09\ \frac{kJ}{kg-K})(315 - 207.3) = \frac{(710)}{1000}\ \frac{kW}{m^2-°C}\ (A)(172°C)$

$A = 22.79\ m^2$

315 → 150
28 → 207.3

$\Delta T_1 = 315 - 150 = 165$
$\Delta T_2 = 207.3 - 28 = 179.3$

$LMTD = \frac{179.3 - 165}{\ln(\frac{179.3}{165})} = 172$

14. Component of absorption refrigeration system in which the solution is cooled by cooling water.

A. Absorber
B. Rectifier
C. Evaporator
D. Generator

15. If the ultimate strength drops by 30% , the steam temperature rises from _____ for unalloyed steel.

A. 400 to 500°C
B. 300 to 400°C
C. 500 to 600°C
D. 600 to 700°C

16. The Coefficient of Performance (COP) of actual absorption refrigeration system is usually _____.

A. less than 1
B. greater than2
C. less than 3
D. less than 4

17. Two-stroke engine performs _____ to complete one cycle.

A. compression & power
B. suction and discharge stroke
C. power and exhaust stroke
D. suction and exhaust stroke

18. These are steam generators used by utilities for electric-power generating plants.
    A. Utility steam generators
    B. Water- tube boilers
    C. Industrial steam generators
    D. Fire tube boilers

19. Calculate the heat transfer rate, in KW during a steady state operation of a gearbox which receives 60 kW through the input shaft and delivers power through the output shaft. And for the gearbox as the system, the rate of energy transfer is by convection, h = 0.171 kW/m2-K which is the heat transfer coefficient , A = 1.0 m2 which is the outer surface area of the gearbox, Tb = 300K (27C) which is the temperature at the outer surface and , Tf = 293K (20C) which is the temperature of the surroundings away from the immediate vicinity of the gearbox.

A. 1.3 kW
B. - 1.2 kW
C. 1.5 kW
D. + 2.1 kW

$$Q = h A (T_f - T_b)$$

$$= \left(0.171 \frac{kW}{m^2 \cdot K}\right)(1\ m^2)(293 - 300)\ K$$

$$= -1.2\ kW$$

20. What is the color code for the cylinder of R-22?

A. Green
B. Silver
C. Orange
D. White

REFRIGERANT NO.	CYLINDER COLOR
R-11	ORANGE
R-113	PURPLE
R-114	DARK BLUE
R-123	SILVER
R-12	WHITE
R-22	GREEN
R-134a	SKYBLUE
R-500	YELLOW
R-502	ORCHID
R-717	SILVER
R-13	PALE BLUE
R-503	AQUAMARINE

21. Foundation bolts of specified size should be used and surrounded by a pipe sleeve with an inside diameter of at least
   A. 2 times the diameter of anchor bolt
   B. 2 times the diameter of engine bolt
   C. 3 times the diameter of anchor bolt
   D. 3 times the diameter of engine bolt

22. One of the following valves that should be used in a steam line to throttle the flow is the _____valve.

A. gate
B. check
C. plug
D. globe

23. The most likely cause of black smoke exhausting from the chimney of an oil-fired boiler is:

A. low oil temperature
B. high secondary airflow
C. low stack emission
D. hygrometer

24. A stainless steel tank contains liquid nitrogen at -190°C is suspended in a vacuum shell by three stainless steel rods 0.80 cm in diameter and 3 meters long with a thermal conductivity of 16.3 W/m2-°C. If the ambient air outside the vacuum shell is 15°C, find the magnitude of the conductive heat flow in watts along the support rods.

A. 0.168
B. 0.176
C. 0.182
D. 0.187

$$Q = h A \Delta T$$

$$= \left(16.3 \frac{W}{m^2 \cdot °C}\right)\left(\frac{\pi}{4}\left(\frac{0.8}{100} m\right)^2\right)\left(15° - (-190)\right)°C$$

$$= 0.168 \text{ W}$$

25. You are working the 4:00 PM to Midnight shift at an energy producing, coal burning steam plant. The first thing you would do when coming to work is:

A. blow down gauge glass & determine water level → DAILY/WEEKLY
B. clean the fires → WEEKLY/MONTHLY
C. add green coal and build up the fire
D. blow down the boiler → EVERY 8 HOURS

once every 8 hour shift

How often should a boiler have a bottom blowdown? The most common recommendation for the frequency of **bottom blowdown** of a steam **boiler** is at least once every 8 hour shift.

26. One insulated wall of a new cold-storage compartment is 8 m long by 2.5 m high and consists of an outer steel plate 1.8 cm thick. An inner wood wall 2.25 cm thick, the steel and wood are 9.0 cm 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. 508.24 kJ, 14.12°C
C. 608.24 kJ, 13.12°C
B. 708.24 kJ , 11.12°C
D. 408.24 kJ , 12.12°C

Continued on Page 4

$Q_T = Q_C = Q_S = Q_W$

$$Q_C = \frac{A\,\Delta T_C}{\frac{x_C}{k_C}}$$

$$141.176 = \frac{(8 \times 2.5)\,\Delta T_C}{\frac{0.09}{0.045}}$$

$$\Delta T_C = 14.12\,^{\circ}C$$

$$Q_T = \frac{A\,\Delta T}{\frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3}}$$

$$= \frac{(8 \times 2.5)(15)}{\frac{0.018}{45} + \frac{0.09}{0.045} + \frac{0.0225}{0.18}}$$

$$= 141.176 \frac{J}{s} \times \frac{3600\,s}{hr} \times \frac{1\,kJ}{1000\,J}$$

$$= 508.24\ kJ/hr$$

27. One advantage of a low-side float system is that it:

A. requires a large amount of refrigerant
B. can be used with a low starting torque motor
C. eliminates flash gas in the evaporator
D. can be used with a water cooled condenser

28. One disadvantage of a low-side float valve is that it:
    A. cannot be used on multiple system
    B. is nonadjustable
    C. is very expensive
    D. requires a large amount of refrigerant

29. An air cooled condenser vacuum gauge reads 715 mm Hg when the barometer stands at 757 mmHg. Find the absolute pressure in the air cooled condenser in kN/m2 or kPa.

A. 6.9 kPa
B. 9.5 kPa
C. 6.5 kPa
D. 5.6 kPa

$$P_{abs} = P_{atm} - P_{VAC}$$

$$= (757 - 715)\ \text{mmHg} \times \frac{101.325\ \text{kPa}}{760\ \text{mmHg}}$$

$$= \boxed{5.6\ \text{kPa}}$$

30. Where objects are to be cooled to temperature below _____ , cascade refrigeration cycle is often used in industrial process?

A. -46 °C
B. -26 °C
C. -36 °C
D. -66 °C

31. A hot suction line might be caused by:

A. insufficient lubrication
B. expansion valve closed too much
C. insufficient refrigerant
D. too much refrigeration

32. What is the color code of compressed air pipelines?
A. brown
B. red
C. light blue
D. violet

33. In a hydro-electric plant using a Francis turbine with medium head, the speed can be regulated using the:
A. wicket gate
B. nozzle
C. weir
D. deflector gate

34. In Brayton cycle, the heat is transformed during what process?
A. isochoric process
B. isobaric process
C. isentropic process
D. constant temperature

PIPING

GREEN	Water
SILVER-GRAY	Steam
VIOLET	Acid/Alkali
LIGHT BLUE	Air
LIGHT ORANGE	Electricity
WHITE	Communications
BROWN	Flammable, Oil
YELLOW OCHRE	Gases
BLACK	Other Fluids, Drainage
SAFETY RED	Fire fighting
SAFETY YELLOW	Hazardous

35. What is the color code for the cylinder of ammonia?
   A. Orange
   B. Green
   C. Silver
   D. White

→ NH_3

$14 + 3(1) = 17$

R-717

36. In accordance with recommended practice, a sample of boiler water for pH analysis should be taken:
   A. when the steaming rate is high
   B. prior to putting the boiler on the line
   C. immediately after chemicals should be taken
   D. just before bottom blow down

37. How many watts will be radiated from a steady spherical black body having a 150 mm in diameter at a temperature of 910°C ?
   A. 8.79 kW
   B. 5.34 kW
   C. 7.89 kW
   D. 3.45 kW

$$Q_{RAD} = \varepsilon A_s \theta T^4 \quad (A_s = \pi D^2)$$

$$= (1)\left(\pi (0.15)^2 \, m^2\right)\left(5.67 \times 10^{-8} \, \frac{W}{m^2 \cdot K^4}\right)(910 + 273)^4 \, K^4$$

$$= 7849.7 \text{ W}$$

$$= 7.85 \text{ kW}$$

REFRIGERANT NO.	CYLINDER COLOR
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R-500	YELLOW
R-502	ORCHID
R-717	SILVER
R-13	PALE BLUE
R-503	AQUAMARINE

38. What will be the weight of 30 lbm, if its weighed on the moon? (gmoon = 5.47 ft/s2).
   A. 4.1 lbf
   B. 3.1 lbf
   C. 2.1 lbf
   D. 5.1 lbf

39. The unit of measurement for current flow. The magnitude is determined by the number of electrons passing a point at a given time.
   A. Ohm
   B. Ampere
   C. Wattage
   D. Voltage

40. Two-stroke engine performs _____ to complete one cycle.
   A. compression & power stroke
   B. suction and discharge stroke
   C. power and exhaust stroke
   D. suction and exhaust stroke

41. What will be the pressure at 7000 ft below the water surface of the ocean? Neglect compressibility.
   A. 213,000 psf
   B. 512,000 psf
   C. 324,500 psf
   D. 447,000 psf

$W_M = m g_m$

$= (30\,lb)(5.47\,ft/s^2)$

$\frac{}{32.2\,lb_m\text{-}ft/s^2}$

$= 5.1\,lb_F$

$P = \gamma_{sw} h$

$= (SG\,\gamma_w)\,h$

$= (1.023)\left(62.4\,\frac{lb}{ft^3}\right)(7000\,ft) = 446,846.4 \approx 447,000\,psf$

42. A knocking noise in steam lines is generally the result of:
   A. superheated steam expansion
   B. condensation in the line
   C. high steam pressure
   D. rapid steam expansion

43. During takeoff in a spaceship, an astronaut is subjected to acceleration equal to 5 times the pull of the earth's standard gravity. If the astronaut is 180 lbm and the takeoff is vertical, what force does he exert on the seat?
   A. 8829 N
   B. 9620 N
   C. 4810.9 N
   D. 4414.5 N

$$\Sigma F_y = 0$$

$$F = W + REF$$

$$= mg + ma$$

$$= m(a + g) \quad (a \to 5g)$$

$$= \frac{180}{2.2}\ kg\ (5(9.8) + 9.8)\ m/s^2 = \boxed{4810.9\ N}$$

44. In power plants, boiler feed water is chemically treated in order to:
A. prevent scale formation
B. increase the temperature of the water
C. increase oxygen formation
D. increase water foaming

45. When the temperature of stack gases rises considerably above the normal operating stack temperature, it generally indicates:
A. that the boiler is operating efficiently
B. a low boiler water level
C. a heavy smoke condition in the stack
D. that the boiler tubes are dirty

46. A high discharge type of turbine
A. Impulse turbine
B. Deriaz turbine
C. Francis turbine
D. Propeller turbine

47. The solenoid valve controls the:
A. amount of refrigerant entering the evaporator coils
B. amount of refrigerant going to the compressor
C. amount of refrigerant going to the expansion valve
D. pressure of the refrigerants going to the evaporator coils

48. The sound power level of a VAV Box (Variable Air Volume) depends mainly on Volume flow of supply air for a specific size box, configuration of the VAV box, flexible ducts, diffusers and what other factor?

A. Difference in static pressure across the VAV box in WC.

Continued on Page 6

B. Configuration of the Damper actuator of the VAV box.
C. Psychrometric properties of air entering the VAV box.
D. Fan Speed in RPM of the VAV fan.

49. Calculate 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 Pt = 100 kPa.

A. 0.79 m3/kg
B. 0.92 m3/kg
C. 0.89 m3/kg
D. 0.69 m3/kg

$$v = \frac{RT}{P_t - P_v}$$

$$w = \frac{0.622\,P_v}{P_t - P_v}$$

$$v = \frac{\left(0.287 \frac{kPa\text{-}m^3}{kg\text{-}K}\right)(30+273)K}{(100 - 2.355)\,kPa}$$

$$0.015 = \frac{0.622\,P_v}{100 - P_v}$$

$$P_v = 2.355\ kPa$$

$$= 0.89\ m^3/kg$$

50. A 4 meter x 5 meter x 6 meter special storage room is to be heated by a baseboard resistance heater. It is desired that the resistance heater be able to raise the air temperature in the special storage room from 7°C to 23°C within 15 minutes. Assuming no heat losses from the special storage room and an atmospheric pressure of 100 kpa, determine the required power of the resistance heater. Constant specific heats at room temperature to be assumed.

A. 4.56 KW
B. 1.91 KW
C. 2.34 KW
D. 6.34 KW

$$\dot{Q} = \dot{m} C_v \Delta T$$

$$\dot{m} = \frac{m}{t} = \frac{\frac{PV}{RT}}{t} = \frac{\frac{(100)(4\times5\times6)}{0.287(7+273)}\ kg}{15\ \text{min} \times \frac{60\ s}{1\ \text{min}}} = 0.1659\ kg/s$$

$$= \left(0.1659\ \frac{kg}{s}\right)\left(0.7186\ \frac{kJ}{kg\cdot K}\right)(23-7)\ K$$

$$= 1.91\ kW$$

51. In an experiment to determine the calorific value of an oil fuel by means of a bomb calorimeter, the mass of the sample of fuel is 0.75 gram, mass of water surrounding the bomb 1.8 kg, water equivalent of bomb and fittings 470 grams, and the rise in temperature is 3.3°C. What is the calorific value of this oil in MJ/kg assuming a specific heat of water= 4.2 kJ/kgK.

A. 25.63MJ/kg
B. 32.15MJ/kg
C. 65.63MJ/kg
D. 41.94MJ/kg

$$Q_H = \frac{Q}{m_F} = \frac{mC\Delta T}{m_F} = \frac{(1.8 + 0.47)\,kg\,\left(4.2\,\frac{kJ}{kg\cdot K}\right)(3.3)\,K}{\frac{0.75}{1000}\,kg}$$

$$= 41,949.6\,\frac{kJ}{kg} \times \frac{1\,MJ}{1000\,kJ}$$

$$= 41.9496\,\frac{MJ}{kg}$$

52. Based on industry practice, for a specified amount of compressed air, the power consumption of the compressor decreases by _____ for each 3°C drop in the temperature inlet air to the compressor.

A. 2.0 percent
B. 1.5 percent
C. 2.5 percent
D. 1.0 percent

53. A pressure cooker operates by cooking food at a higher pressure and temperature than is possible at atmospheric conditions. Steam is contained in the sealed pot, with vent hole in the middle of the cover, allowing steam to escape. The pressure is regulated by covering the vent hole with a small weight, which is displaced slightly by escaping steam. Atmospheric pressure is 100 kPa, the vent hole area is 7-mm2, and the pressure inside should be 250 kPa. What is the mass of the weight?

A. 0.1783 kg
B. 1.05 kg
C. 1.75 kg
D. 0.107 kg

$$\Delta P = \frac{F}{A} \quad \rightarrow N = mg$$

$$\Delta P = \frac{mg}{A}$$

$$\frac{(250-100)\ \frac{kN}{m^2}}{1000} = \frac{m\,(9.81\ m/s^2)}{7\ mm^2 \times \left(\frac{1\ m}{1000\ mm}\right)^2}$$

$$m = 0.107\ kg$$

54. In a flooded evaporator using an accumulator and float valve, flash gas:
A. passes directly into the suction line
B. does not occur
C. stays in the receiver
D. passes directly into the evaporator

55. The applications and joining methods for this pip are very similar to those for PVC. However, this pipe can be used for hot water (up to 180 oF) in a pressurized system (up to 100 psi).
A. Chlorinated Polyvinyl Chloride (CPVC)
B. Polyvinyl Chloride (PVC) pipe
C. Polyetheyene (PE) pipe
D. Acrylonitrilebutadiene Styrene(ABS) pipe

Continued on Page 7

56. An hydraulic turbine which has a diameter of 60 in., speed of 350 rpm, coefficient of velocity of 0.98, peripheral speed factor of 0.45, generator efficiency of 90% and jet diameter from nozzle of 6 in. Determine the power input in hp.

A. 2933
B. 2366
C. 2862
D. 2512

$$P = \gamma Q h$$

$$= \frac{(62.4\ \text{lb/ft}^3)(39.18\ \text{ft}^3/\text{s})(643.817\ \text{ft})}{550\ \text{lb-ft/s/HP}}$$

$$= 2862\ \text{HP}$$

$$\phi = \frac{\pi D N}{\sqrt{2gh}}$$

$$0.45 = \frac{\pi\left(\frac{60}{12}\right)\text{ft}\left(\frac{350}{60}\right)\text{r/s}}{\sqrt{2 \times 32.2 \times h}}$$

$$h = 643.817\ \text{ft}$$

$$Q = C_v A\sqrt{2gh}$$

$$= (0.98)\left(\frac{\pi}{4}\left(\frac{6}{12}\right)^2\text{ft}^2\right)\sqrt{2 \times 32.2 \times 643.817}\ \text{ft/s}$$

$$= 39.18\ \text{ft}^3/\text{s}$$

57. Pure water enters a 3cm diameter copper tube with a velocity of 50m/s and a temperature of 20oC and is heated. What is the average unit convective coefficient. For water, kinematic viscosity= 1.006x10-6m2/s; prandtl number=7; and thermal conductivity=0.597W/m-K.

A. 23.45
B. 123.54
C. 76.12
D. 86.6kW/m2-K

$Nu = 4.36$ (FOR WATER)

$$h = \frac{Nu\ k}{D}$$

$$= \frac{(4.36)\left(0.597 \frac{W}{m-K}\right)}{\frac{3}{100}\ m} = 86.76 \frac{W}{m^2-K}$$

58. The journals of a stainless steel shaft are 38.0 cm 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. 501.575 kJ
B. 505.575 kJ
C. 501.375 kJ
D. 401.375 kJ

$$T_f = F \times r \times f$$

$$= (200{,}000\ N)\left(\frac{380\ mm}{2}\right) \times 0.02 = 760{,}000\ N\text{-}mm$$

$$P = \frac{TN}{9.549 \times 10^6}$$

$$= \frac{760{,}000 \times 105}{9.549 \times 10^6} = 8.357\ \frac{kJ}{s} \times \frac{60\ s}{min} = \boxed{501.41\ \frac{kJ}{min}}$$

59. An insulated steam pipe located where the ambient temperature is 32°C, has an inside diameter of 5.0 cm with 1.0 cm thick wall. The outside diameter of the corrugated asbestos insulation is 12.5 cm and the surface coefficient of still air, ho = 12 W/m2-K.
Inside the pipe is steam having a temperature of 170°C with film coefficient hi = 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. 120 W
B. 110 W
C. 130 W
D. 140 W

$r_1 = \frac{5}{2} = 2.5\text{cm}$

$r_2 = r_1 + 1 = 2.5 + 1 = 3.5\text{cm}$

$r_3 = \frac{12.5}{2} = 6.25\text{cm}$

$$\frac{Q}{L} = \frac{\Delta T}{\frac{1}{A_i h_i} + \frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi k_1} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2\pi k_2} + \frac{1}{A_o h_o}}$$

$A_i = \pi D_1 L$, $A_o = \pi D_3 L$

$$= \frac{(170 - 32)}{\frac{1}{(\pi)(0.05)(6000)} + \frac{\ln\left(\frac{3.5}{2.5}\right)}{2\pi(45)} + \frac{\ln\left(\frac{6.25}{3.5}\right)}{2\pi(0.12)} + \frac{1}{\pi(12.5)(12)}}$$

$$= 140\ \text{W}$$

60. What is the color code for the cylinder of R-134a?

A. Orange
B. Green
C. Silver
D. Light blue

REFRIGERANT NO.	CYLINDER COLOR
R-11	ORANGE
R-113	PURPLE
R-114	DARK BLUE
R-123	SILVER
R-12	WHITE
R-22	GREEN
R-134a	SKYBLUE
R-500	YELLOW
R-502	ORCHID
R-717	SILVER
R-13	PALE BLUE
R-503	AQUAMARINE

61. You are working the 4:00 PM to Midnight shift at an energy producing, coal burning steam plant. The first thing you would do when coming to work is:
   A. clean the fires
   B. add green coal and build up the fire
   C. blow down the boiler
   D. blow down gauge glass & determine water level

62. What other factor will the sound power level of a Variable Air Volume Box depends other than the volume flow of supply air for a specific size box, configuration of the variable air volume box, flexible ducts and diffusers?
   A. Difference in static pressure across the VAV box in WC.
   B. Psychrometric properties of air leaving the VAV box.
   C. Design of the VAV fan
   D. Design configuration of the Damper of the VAV box.

63. The bottom blow down on a boiler is used to:
   A. reduce steam pressure in the header
   B. increase boiler priming
   C. increase the boiler water level
   D. remove mud drum water impurities

Continued on Page 8

64. The moisture content of the boiler at exit will be _____ , by also increasing the boiler pressure in Rankine Cycle.

A. increase
B. decrease
C. equally
D. remains the constant

65. Pure steam at a pressure of 30 bar, and at a temperature of 375°C, is generated in a boiler at the rate of 30000 kg/h from feed water at a temperature of 130°C. The fuel has a calorific value of 42 MJ/kg and the daily consumption is 53 tonne. What will be the equivalent engine power if the overall efficiency of the plant is 0.13.

A. 2546kW
B. 5634kW
C. 8954kW
D. 3349kW

M.ton

$$e = \frac{P_e \rightarrow P_{OUTPUT}}{m_F Q_h \rightarrow P_{INPUT}}$$

$$0.13 = \frac{P_e}{\left(53 \frac{M.ton}{day}\right)\left(42 \frac{MJ}{kg}\right) \times \frac{1\,day}{24\,hr} \times \frac{1\,hr}{3600\,s} \times \frac{1000\,kg}{M.ton} \times \frac{1000\,kJ}{MJ}}$$

$$P_e = 3349\ kW$$

66. Neil Armstrong, an astronaut is subjected to an acceleration equal to 5 times the pull of the earth's standard gravity, during the take off of a spaceship. If the said astronaut is 180 lbm and the take off is vertical, determine force does he exert on the seat.

A. 4414.5 N
B. 8829 N
C. 4810.9 N
D. 9620 N

$$\Sigma F_y = 0$$

$$F = W + REF$$

$$= mg + ma \qquad a = 5g$$

$$F = m(a+g)$$

$$= m(5g+g)$$

$$= \frac{180}{2.2}\,kg\,(5 \times 9.81 + 9.81)\,m/s^2 = 4810.9\ N$$

67. The term spalling refers to a boiler:

A. flue gas content
B. mud leg
C. soot blower
D. combustion chamber

68. A newly installed turbine receives 150 lbm/sec of air at a pressure of63 psia and aq temperature of 2450°R and expands it polytropically to a pressure of 14.7 psia. The exponent n is equal to 1.45 for the process. Determine the power required.

A. 53,343.16 kW
B. 53,343.16 ft-lb/sec
C. 52,343.16 BTU/sec
D. 53,343.16 HP

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} \rightarrow \frac{T_2}{2450} = \left(\frac{14.7}{63}\right)^{\frac{1.45-1}{1.45}} \quad ; \quad T_2 = 1559.62\ ^\circ R$$

$$W = \frac{\dot{m} R (T_2 - T_1)}{1-n} = \frac{\left(150 \frac{lbm}{s}\right)\left(53.34 \frac{lb_F - ft}{lbm - {}^\circ R}\right)(1559.62 - 2450)\ ^\circ R}{1 - 1.45}$$

$$W = 40722956.4 \frac{ft-lb}{s}\left(\frac{1\,BTU}{778\ ft-lb}\right) = \boxed{53,343.13 \frac{BTU}{s}}$$

69. What is the pressure at 12300 ft altitude if air is incompressible, if the atmospheric air 14.7 psia and 60oF at sea level?
Note: @ 60°F ; the density of air is 0.0763 lbm/ft3 ; P1 = 14.7 psia

A. 9.33 psia
B. 9.43 psia
C. 9.63 psia
D. 9.53 psia

$$P_2 = P_1 e^{\frac{-gh}{RT}}$$

$$= (14.7) e^{\frac{-12300}{(53.34)(60+460)}} = 9.43 \text{ psia}$$

70. Blow off piping usually refers to:

A. vent pipes
B. piping coming from the super heater
C. piping coming from the safeties
D. piping at the lowest part of the boiler

71. 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 40°C. A 15.2 cm of refractory silica is used adjacent to the combustion chamber and 1.0 cm 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. 217 mm
B. 218 mm
C. 219 mm
D. 220 mm

$$Q = \frac{\Delta T}{\frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3}}$$

$$788 = \frac{(1200 - 40)}{\frac{0.152}{13.84} + \frac{x_2}{0.15} + \frac{0.01}{45}}$$

$$x_2 = 0.219\ m$$

$$= 219\ mm$$

B. 218 mm

72. A centrifugal boiler feed pump requires 5 hp to drive it at a certain speed, head and discharge rate. If the speed and quantity of water delivered are doubled and the total head quadrupled, the horsepower required will be approximately equal to:

A. 30
B. 10
C. 40
D. 20

Continued on Page 9

$H_2 = 4H_1$ $N_2 = 2N_1$

Q	H	P
1	2	8
3	2	5

N
D

$$\frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3 \left(\frac{D_2}{D_1}\right)^5$$

$$\frac{H_2}{H_1} = \left(\frac{D_2}{D_1}\right)^2 \left(\frac{N_2}{N_1}\right)^2$$

$$\frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3$$

$$4 = \left(\frac{D_2}{D_1}\right)^2 (2)^2$$

$$\frac{P_2}{5} = (2)^3$$

$$D_2 = D_1$$

$$P_2 = 40\ HP$$

73. As a safety precaution, refrigerant cylinders should be stored and transported in the _____ position to keep the pressure relief valve in contact with the vapor space, not the liquid inside the cylinder.

A. Horizontal
B. Any
C. Upright
D. Upside down

74. During hydrostatic test, the safety valves should be

A. removed
B. partially closed
C. open
D. closed

D. closed

75. A college student living in a dormitory room of 4 meters x 6meters x 6meters turns on her 150 watts electric fan before she leaves the room on a summer day, hoping that the room will be cooler when she comes back in the evening. Assuming all the doors and windows are tightly closed and disregarding any heat transfer through the walls and the windows, determine the temperature in the room when she comes back 10 hours later. Use specific heat values at room temperature, and assume the room to be at 100 kpa and 15 °C in the morning when she leaves.

A. 58.13°C
B. 48.13°C
C. 38.13°C
D. 28.13°C

$Q = mC_v(t_2 - t_1)$

$Q = Pt$

$m = \frac{PV}{RT} = \frac{(100)(4\times6\times6)}{0.287\,(15+273)} = 174.216\ kg$

$\left(0.15\ \frac{kJ}{s} \times \frac{3600\,s}{1\,hr} \times 10\,hrs\right) = (174.216\,kg)\left(0.7186\ \frac{kJ}{kg\text{-}K}\right)(t_2 - 15)\,K$

$t_2 = 58.13\ °C$

76. The enthalpy of ground H2O in a 20 MW geothermal power plant is 1000 kJ/kg. If the quality after throttling is 28% & the overall plant efficiency is 20%. What is the mass flowrate of the steam entering the turbine?

A. 18 kg/s
B. 28 kg/s
C. 76 kg/s
D. 24 kg/s

$m_s = m_g x$

$m_g = \frac{20{,}000 \text{ kJ/s}}{(0.2)(1000 \text{ kJ/kg})}$

$= 100 \text{ kg/s}$

$Q_G = m_g h_G$

$m_g = \frac{Q_g}{h_g(0.2)}$

$m_s = (100 \text{ kg/s})(28\%)$

$= 28 \text{ kg/s}$

77. A process of removing heat from a place where it is not wanted and transferring that heat to a place where it makes little or no difference.

A. Air conditioning
B. Convection
C. Conduction
D. Refrigeration

78. The mass analysis of a fuel is 84% carbon, 14% hydrogen and 2% ash. It is burned with 20% excess air relative to stoichiometric requirement. If 100 kg/h of this fuel is burned in a boiler , what is the volumetric flow rate of the gas if its temperature and pressure are 250°C and 1 bar respectively?
Note: Air contains 23.1% oxygen by mass. Ro= 8.3143 kJ/kg mol K and atomic mass relationships are: oxygen 16, carbon 12, hydrogen 1.

A. 2569m3/hr
B. 5689m3/hr
C. 2759m3/h
D. 1256m3/hr

$$\frac{A}{F} = 11.5\,C + 34.5\left(H - \frac{O}{8}\right) + 4.3\,S$$

$$= 11.5(84\%) + 34.5\left(14\% - \frac{0}{8}\right) + 4.3\,(0)$$

$$= 14.49$$

$$\left(\frac{A}{F}\right)_{ACTUAL} = (14.49)(1.2) = 17.388$$

$$m_A + m_F = m_g$$

$$m_A = \left(\frac{A}{F}\right) m_F = (17.388)\left(100\ \frac{kg}{h}\right)$$

$$= 1738.8\ \frac{kg}{h}$$

$$m_g = 1738.8 + 100 = 1838.8\ kg/h$$

$$PV = m_g R T$$

$$(100)(V) = \left(1838.8\ \frac{kg}{h}\right)(0.287)(250+273)$$

$$V = 2760\ \frac{m^3}{hr}$$

79. The mass flow rate of Freon 12 through a heat exchanger is 10 lbs/min. Enthalpy of Freon entry is 102 BTU/lb and of Freon exit is 26 BTU/lb. Water coolant is allowed to rise 10 deg F. The water flow rate in liters per minute is:

A. 76
B. 54.3
C. 34.5
D. 83

$$Q_F = Q_W \rightarrow \rho \dot{V}$$

$$m_F (h_1 - h_2) = m_W C_p (T_2 - T_1)$$

$$\left(10 \frac{lb}{min}\right)(102-26)\frac{BTU}{lb} = \left(62.4 \frac{lb}{ft^3}\right)\dot{V}\left(\frac{1\ BTU}{lb \cdot {}^\circ F}\right)(10\ {}^\circ F)$$

$$\dot{V} = 1.2179\ ft^3/min \times \left(\frac{1\ m}{3.281\ ft}\right)^3 \times \frac{1000\ L}{m^3}$$

$$= 34.48\ L/min$$

80. Hot gasses at a temperature of 280 °C flow on one side of a metal plate of 1.0 cm 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 48 W/m2-K. Calculate the over-all transfer coefficient.

A. 18.94 W/m2-K
B. 15.82 W/m2-K
C. 81.25 W/m2-K
D. 91.48 W/m2-K

Continued on Page 10

$$U = \frac{1}{R_T}$$

FOR METAL PLATE:

$$k = 50 \frac{W}{m\text{-}K}$$

$$R_T = \frac{1}{h_1} + \frac{x}{k} + \frac{1}{h_2}$$

$$= \frac{1}{31.5} + \frac{0.01}{50} + \frac{1}{48}$$

$$= 0.0528$$

$$U = \frac{1}{0.0528} = 18.94 \frac{W}{m^2\text{-}K}$$

81. Tubing used for air conditioning installations is usually insulated at:
   A. Any of these
   B. the discharge line
   C. the low-pressure side
   D. the high-pressure side from the condenser to the metering device

82. Piping installation crossing an open space that affords passageway in any building shall be not less than _____ above the floor unless the piping is located against the ceiling of such space and is permitted by the authority having jurisdiction.
   A. 2.2 m
   B. 3.5 m
   C. 4.2 m
   D. 5.5 m

83. The refrigerant used in steam jet cooling is:
   A. Water
   B. R-11
   C. Ammonia
   D. Steam

84. Calculate the air-fuel ratio on a molar basis for the complete combustion of octane gas , with theoretical amount of air.

A. 69.5 kgair / kgfuel
B. 49,5 kgair / kgfuel
C. 59.5 kgair / kgfuel
D. 95.5 kgair / kgfuel

$C_n H_{(2n+2)}$

$C_8 H_{18}$ $\quad x = n + \frac{m}{4}$

$= 8 + \frac{18}{4} = 12.5$

$$\left(\frac{A}{F}\right)_{MOLAR} = 4.76x = 4.76(12.5) = 59.5 \ \frac{k_{gA}}{k_{gF}}$$

85. The discharge line (B4) shall be vented to the atmosphere through a _____ fitted to its upper extremity.

A. vent pipe
B. diffuser
C. jet nozzle
D. convergent-divergent nozzle

86. A stainless steel cylindrical with 1 ft diameter , 4 ft high tank contains 3 ft of water. What rotational speed is required to spin water out the top?

A. 7.22 rad/s
B. 27.2 rad/s
C. 22.7 rad/s
D. 72.2 rad/s

$h = \frac{v^2}{2g}$

$v = r\omega$

ω → ROTATIONAL SPEED

$\frac{h}{2} = (4-3)$

$h = 2$ ft

$2 = \frac{(0.5\omega)^2}{2 \times 32.2}$

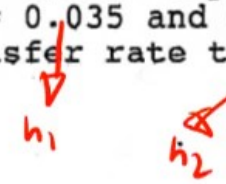
$\omega = 22.7$ rad/s

87. Freon is:

A. non-corrosive
B. nontoxic
C. flammable
D. all of these

88. A V-type 3.0 liter, 5-cylinder, 4-stroke cycle SI engine, with a volumetric efficiency of 82%, operates at 3000 RPM using gasoline with a ? = 0.91. Bore and stroke are related as S = 1.08B. At a certain point in the engine cycle, the gas temperature in the combustion chamber is Tg = 2100°C while the cylinder wall temperature is TW = 190°C. Viscosity, and Thermal conductivity, of gases (air at 1145°C) ?g = 5.21x10-5 kg/m-sec, kg = 0.090 W/m-K respectively. Convective heat transfer coefficient of c1 = 0.035 and c2 = 0.08. Compute the approximate convection heat transfer rate to the cylinder wall at this instant.

A. 35.44 kW/m2
B. 54.32 kW/m2
C. 32. 54 kW/m2
D. 45.52 kW/m2



ASSUME $x = 8\ cm$

$$Q = \frac{\Delta T}{\frac{1}{h_1} + \frac{x}{k} + \frac{1}{h_2}} = \frac{2100 - 190}{\frac{1}{0.035} + \frac{0.08}{0.09} + \frac{1}{0.08}}$$

$$= 45.52\ W/m^2$$

89. _____ consist of refrigerant mixtures of two or more different chemical compounds, often used individually as refrigerants for other applications.

A. compound reaction
B. absorbtion
C. mixing of refrigerants
D. blends

Continued on Page 11

90. An economizer is used with a steam boiler in order to raise the temperature of the:

A. boiler feed water by utilizing exhaust steam from the turbines or steam engines
B. air used for combustion of the fuel utilizing some of the heat in the exit flue gases
C. air used for combustion of the fuel utilizing exhaust some steam from the turbines or steam engines
D. boiler feed water by utilizing some of the heat in the exit flue gases

91. Fuel oil is heated in a storage tank by use of:
A. fuel oil burner
B. steam
C. hot air
D. electric coils

92. If Joule Thompson coefficient is equal to zero, then the process will become
A. isobaric
B. isenthalpic
C. isothermal
D. isentropic

93. As a rule of thumb, for a specified amount of compressed air, the power consumption of the compressor decreases by _____ for each 3°C drop in the temperature inlet air to the compressor.
A. 2 percent
B. 1.5 percent
C. 1 percent
D. 2.5 percent

94. A nozzle receives 0.5 kg/s of air at a pressure of 2700 kPa and a velocity of 30 m/s and with an enthalpy of 923 kJ/kg, and the air leaves at a pressure of 700 kPa and with an enthalpy of 660 kJ/kg. Determine the exit velocity from the nozzle.

A. 700 m/s
B. 923 m/s
C. 726 m/s
D. 660 m/s

$$h_1 + \frac{V_1^2}{2000} = h_2 + \frac{V_2^2}{2000}$$

$$923 + \frac{30^2}{2000} = 660 + \frac{V_2^2}{2000}$$

$$V_2 = 726 \text{ m/s} //$$

95. Which of the following is NOT the cause of black smoke in diesel engine?

A. carbon in exhaust pipe
B. overload on engine
C. high compression pressure
D. fuel valve open too long

96. A fresh supply of 50 kilograms chicken at 6oC contained in a box is to be frozen to -18°C in a electric freezer. What will be the amount of heat that needs to be removed? The latent heat of the chicken is 247 KJ/kg, and its specific heat is 3.32 KJ/kg-C above freezing and 1.77 KJ/kg-C below freezing. The container box is 1.5 kilograms, and the specific heat of the box material is 1.4 KJ/kg-C. And the freezing temperature of chicken is -2.8°C.

A. 15,206.4 KJ
B. 11,863 KJ
C. 15,156 KJ
D. 1250 KJ

$Q_T = Q_C + Q_B$

$= 15,156 + 50.4$

$= 15,206.4\ kJ$

$Q_C = RE = m\left[C_{P\,ABOVE}(t_1 - t_F) + L_F + C_{P\,BELOW}(t_F - t_2)\right]$

$= 50kg\left[3.32(6-(-2.8)) + 247 + 1.77(-2.8-(-18))\right]$

$= 15,156\ kJ$

$Q_B = m C_B \Delta T$

$= 1.5\,kg\left(1.4\,\frac{kJ}{kg\cdot°C}\right)(6-(-18))°C = 50.4\ kJ$

97. In which direction does heat flow?

A. Down
B. From warm substance to a cold substance
C. From a cold substance to a warm substance
D. Up

98. If the specific gravity of mercury is SP = 13.55 , what is the specific weight of mercury?

A. 139.2 kN/m3
B. 193.2 kN/m3
C. 123.9 kN/m3
D. 132.9 kN/m3

Continued on Page 12

$$\gamma_M = (S.G.)\,\gamma_W$$

$$= (13.55)\left(9.81 \frac{kN}{m^3}\right)$$

$$\approx 132.9\ kN/m^3 \;//$$

99. What kind of refrigerant is R-600?
A. Methane
B. Nonane
C. Butane
D. None of these

100. Among the four(4), which of the following is not a method of starting diesel engine?
A. Compressed air
B. Manual: rope, crank and kick
C. Electric (battery)
D. Using another engine

*** E N D ***

WARNING: **Failure to submit your Test Questions (Complete) set will cause the cancellation of your Test-Results for the subject.**