Thermodynamics (XE-E)

Given $d\phi = f(T)dT + (T/V)dV$ and $d\psi = Tdp + (T/p^2)dV$, then

(A) both ϕ and ψ are properties
(B) neither ϕ nor ψ is a property
(C) ϕ is a property but ψ is not a property
(D) ψ is a property but ϕ is not a property

A paddle wheel is installed in a rigid insulated tank containing 10 kg air ($C_v = 0.718$ kJ/kg.K). A torque of 100 N.m is applied on the paddle wheel to rotate it at 60 revolutions per minute for 2 minutes. At the end of the process, the increase in temperature of air in °C is

(A) 0   (B) 5.25   (C) 10.50   (D) 21.50

Consider two systems each containing 20 kg of air at the same temperature and pressure. It is desired to increase the temperature of the air in both systems by 10°C. One system undergoes a constant pressure heat addition process and the other undergoes a constant volume heat addition. The difference in the values of heat transferred to the two systems in kJ is

(A) 30.5   (B) 44.2   (C) 57.5   (D) 73.2

A refrigerator is used to maintain certain space at 10°C. It pumps 18000 kJ/hour of heat from the space to the atmosphere at 30°C. If the power input to the refrigerator is 2 kW, the ratio of COP of this refrigerator to that of a Carnot refrigerator (up to 2 decimal places) is _____.

A thermal cycle receives 2000 kJ of heat from a heat source at 1000 K. It rejects 300 kJ of heat to a heat sink at 300 K and also rejects 250 kJ of heat to another heat sink at 200 K during the cycle. The cycle is

(A) reversible   (B) irreversible   (C) impossible   (D) work absorbing

Saturated liquid water is slowly heated at a constant pressure of 200 kPa to a final state where its quality reaches 0.65. For water at 200 kPa: T_{sat} = 120.23°C, h_f = 504.68 kJ/kg, h_g = 2706.60 kJ/kg. The change in the specific entropy in kJ/kg.K is

(A) 3.04   (B) 3.24   (C) 3.44   (D) 3.64

Given the thermodynamic functional relations: $p = p(v,T)$ and $T = T(p,v)$, the term $\left.\dfrac{\partial p}{\partial v}\right|_T \times \left.\dfrac{\partial v}{\partial T}\right|_p$ is equal to

(A) $-\left(\left.\dfrac{\partial T}{\partial p}\right|_v\right)^{-1}$ (B) $\left(\left.\dfrac{\partial T}{\partial p}\right|_v\right)^{-1}$ (C) $\left(\left.\dfrac{\partial T}{\partial p}\right|_v\right)$ (D) 1

Two closed cycle gas turbine engines, A and B, operate on air standard Brayton cycle with efficiencies of η_A and η_B, respectively. If they operate between the same maximum and minimum temperatures, but with different pressure ratios of r_{pA} and r_{pB}, $(r_{pA} > r_{pB})$, then,

(A) $\eta_A = \eta_B$
(B) $\eta_A > \eta_B$
(C) $\eta_A < \eta_B$
(D)   cannot be determined as the efficiencies are maximum only at the optimal r_p values.

The values of density and isentropic compressibility of water at certain pressure and temperature are given as 1000 kg/m³ and 40×10^{-10} Pa^{-1}, respectively. The speed at which sound travels in water under these conditions in m/s is equal to _____.

Length of a certain metal rod at 0 °C is 10 cm. The coefficient of linear expansion of that metal varies with temperature as $10^{-4} + 10^{-5} \times T$ (cm/cm)/°C. When the length of the metal rod is 10.2 cm, the rise in temperature in °C is _____.

In a polytropic compression process, one kg of an ideal gas having a molecular weight of 40 kg/kmol is compressed from 100 kPa, 300 K to 400 kPa, 360 K. The magnitude of the work in kJ for the process is
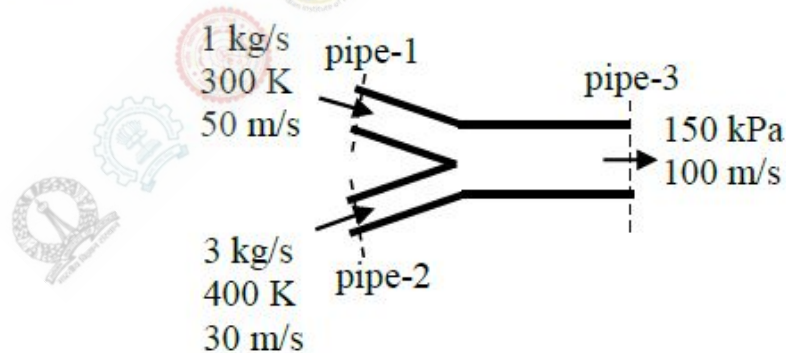
(A) 52.3   (B) 62.3   (C) 72.3   (D) 82.3

Two streams of air (C_p = 1005 J/kg.K) flow through insulated pipes 1 and 2 with the conditions as shown in figure. They mix in an insulated pipe-3 and the mixture steadily exits with a velocity of 100 m/s at 150 kPa. Neglecting the change in potential energy in all the pipes, the exit area of the pipe-3 in m² (up to 3 decimal places) is _____.

A 1 m³ rigid vessel contains air at 200 kPa. A vacuum pump is connected to the vessel in order to control the pressure inside. The volume flow rate of air through the pump is maintained at a constant value of 0.1 m³/s. If the pump operates for 10 seconds and the temperature of the air is maintained constant during operation, the pressure in the tank in kPa after 10 seconds (up to 2 decimal places) is _____.

A heat engine receives Q_1 kJ of heat from a hot reservoir and rejects Q_2 kJ of heat to a cold reservoir. The work delivered by the heat engine is entirely supplied to a heat pump, which receives Q_3 kJ of heat from another reservoir and rejects Q_4 kJ of heat to the same cold reservoir. If the efficiency of the heat engine is 0.4 and COP of the heat pump is 4.0, the value of $(Q_2 + Q_4)/Q_1$ (up to 1 decimal place) is _____.

A block of ice of mass 2 kg at 0°C is dropped into an insulated vessel containing 10 kg of liquid water at 25°C. The latent heat of melting of ice is 330 kJ/kg and specific heat of water is 4.2 kJ/kg.K. The change in the entropy of the universe in kJ/K (up to 3 decimal places) is _____.

A pure substance (C_v = 0.733 kJ/kg.K) undergoes a reversible process in which its temperature increases linearly from 40°C to 85°C and its specific entropy increases by 600 J/kg.K. The work done by the system in kJ/kg is

(A) 160.2   (B) 164.3   (C) 168.3   (D) 172.3

An ideal gas having a mass of 0.5 kg is initially at 300 kPa, 80°C and occupies a volume of 0.14 m³. The gas undergoes an adiabatic process, where 50 kJ of work is transferred to the gas. The pressure and volume at the final state are 300 kPa and 0.20 m³. The change in the entropy of the gas in J/K is

(A) 160.3   (B) 175.3   (C) 190.3   (D) 195.3

The van der Waals equation of state is given as,

$\left(p + \dfrac{a}{v^2}\right)(v - b) = R_u T$, where p in bar, v in m³/kmol and T is in K.

For air, the constants, a and b, are 1.368 bar.(m³/kmol)² and 0.0367 m³/kmol, respectively. Air is contained in a system at 160 K and 0.08 m³/kmol. If p_1 is the pressure calculated using ideal gas equation of state and p_2 is pressure calculated using van der Walls equation of state, then p_1/p_2 is equal to

(A) 1.78   (B) 1.52   (C) 1.28   (D) 1.0

The values of specific volume of H_2O at 100°C for saturated liquid and saturated vapor states are 0.001044 m³/kg and 1.673 m³/kg, respectively. The slope of saturation pressure versus temperature curve, i.e., $(dp/dT)_{sat}$ is 3570 Pa/K. The change in enthalpy in kJ/kg between the two saturation states is _____.

In a steam power plant, steam is first expanded isentropically in a turbine from an initial condition of 100 bar and 500 °C to a pressure of 40 bar. Then the steam is reheated up to 500 °C at constant pressure. The steam is then expanded isentropically in another turbine up to a condenser pressure 0.01 bar. For steam, at 100 bar, 500°C: h = 3373.7 kJ/kg, s = 6.5966 kJ/kg.K; at 40 bar, 500°C: h = 3445.3 kJ/kg, s = 7.0901 kJ/kg.K and at 0.01 bar: h_f = 29.3 kJ/kg, h_g = 2514.2 kJ/kg, s_f = 0.1059 kJ/kg.K, s_g = 8.9756 kJ/kg.K. The dryness fraction at the condenser inlet (up to 2 decimal places) is _____.

Air contains by volume 79% N_2 (molecular weight = 28 kg/kmol) and 21% O_2 (molecular weight = 32 kg/kmol)). A stream of air flows at 32°C, 1 bar, at a rate of 2 m³/s and is mixed with another stream of O_2 flowing at 0.4 kg/s. The molecular weight of the mixture (up to 2 decimal places) is _____.

Moist air enters a duct at a rate of 3 kg/s at 10°C, 80% relative humidity. The air is heated as it flows through the duct and exits at 30°C. No moisture is added or removed and the pressure of air in the duct is constant at 1 bar. The saturation vapor pressure (p_g) of H_2O at 10°C is 0.01228 bar. Specific enthalpy values of dry air at inlet and outlet of the duct are respectively 283.1 kJ/kg and 303.2 kJ/kg. The corresponding specific enthalpy values for water vapor are 2519.8 kJ/kg and 2556.3 kJ/kg. For steady state operation the amount of heat added to the moist air in kW (up to 2 decimal places) is _____.

General Aptitude

The event would have been successful if you _____ able to come.

(A) are   (B) had been   (C) have been   (D) would have been

There was no doubt that their work was <u>thorough</u>.

Which of the words below is closest in meaning to the underlined word above?

(A) pretty   (B) complete   (C) sloppy   (D) haphazard

Question Number : 168 **Correct : 1 Wrong : -0.33**

Four cards lie on a table. Each card has a number printed on one side and a colour on the other. The faces visible on the cards are 2, 3, red, and blue.

Proposition: If a card has an even value on one side, then its opposite face is red.

The cards which MUST be turned over to verify the above proposition are

(A) 2, red   (B) 2, 3, red   (C) 2, blue   (D) 2, red, blue

Question Number : 169 **Correct : 1 Wrong : -0.33**

What is the value of x when $81 \times \left(\frac{16}{25}\right)^{x+2} \div \left(\frac{3}{5}\right)^{2x+4} = 144$?

(A) 1   (B) -1   (C) -2   (D) Cannot be determined

Question Number : 170 **Correct : 1 Wrong : -0.33**

Two dice are thrown simultaneously. The probability that the product of the numbers appearing on the top faces of the dice is a perfect square is

(A) 1/9   (B) 2/9   (C) 1/3   (D) 4/9

Question Number : 171 **Correct : 2 Wrong : -0.66**

Bhaichung was observing the pattern of people entering and leaving a car service centre. There was a single window where customers were being served. He saw that people inevitably came out of the centre in the order that they went in. However, the time they spent inside seemed to vary a lot: some people came out in a matter of minutes while for others it took much longer.

From this, what can one conclude?

(A) The centre operates on a first-come-first-served basis, but with variable service times, depending on specific customer needs.
(B) Customers were served in an arbitrary order, since they took varying amounts of time for service completion in the centre.
(C) Since some people came out within a few minutes of entering the centre, the system is likely to operate on a last-come-first-served basis.
(D) Entering the centre early ensured that one would have shorter service times and most people attempted to do this.

A map shows the elevations of Darjeeling, Gangtok, Kalimpong, Pelling, and Siliguri. Kalimpong is at a lower elevation than Gangtok. Pelling is at a lower elevation than Gangtok. Pelling is at a higher elevation than Siliguri. Darjeeling is at a higher elevation than Gangtok.

Which of the following statements can be inferred from the paragraph above?

    i.   Pelling is at a higher elevation than Kalimpong
    ii.   Kalimpong is at a lower elevation than Darjeeling
    iii.   Kalimpong is at a higher elevation than Siliguri
    iv.   Siliguri is at a lower elevation than Gangtok

(A) Only ii   (B) Only ii and iii   (C) Only ii and iv   (D) Only iii and iv

P, Q, R, S, T and U are seated around a circular table. R is seated two places to the right of Q. P is seated three places to the left of R. S is seated opposite U. If P and U now switch seats, which of the following must necessarily be true?

(A) P is immediately to the right of R
(B) T is immediately to the left of P
(C) T is immediately to the left of P or P is immediately to the right of Q
(D) U is immediately to the right of R or P is immediately to the left of T

Budhan covers a distance of 19 km in 2 hours by cycling one fourth of the time and walking the rest. The next day he cycles (at the same speed as before) for half the time and walks the rest (at the same speed as before) and covers 26 km in 2 hours. The speed in km/h at which Budhan walks is

(A) 1   (B) 4   (C) 5   (D) 6

The points in the graph below represent the halts of a lift for durations of 1 minute, over a period of 1 hour.
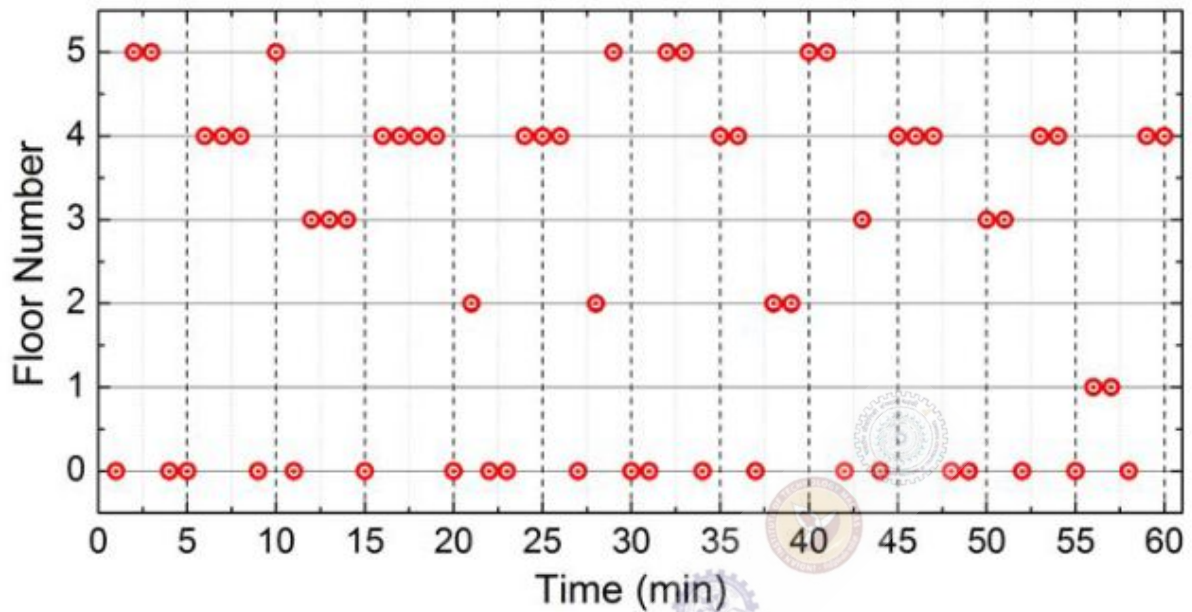
Which of the following statements are correct?

　i.　The elevator never moves directly from any non-ground floor to another non-ground floor over the one hour period

　ii.　The elevator stays on the fourth floor for the longest duration over the one hour period

(A)) Only i　　　　　(B) Only ii　　　　　(C) Both i and ii　　　　　(D) Neither i nor ii