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FREE APP CLASS SCHEDULE

MECHANICAL ENGINEERING

GATE

HMT	MONDAY Live @11AM	YOGESH SIR
PRODUCTION	TUESDAY Live @11AM	GAURAV SIR
SOM	WEDNESDAY Live @8PM	MUKESH SIR
THERMODYNAMICS	THURSDAY Live @11AM	KANISTH SIR
ENGINEERING MATHEMATICS	FRIDAY Live @11AM	ANANT SIR

ISRO | BHEL | DRDO & OTHER PSUs

Thermodynamics

{Open System Analysis}

MOST EXPECTED QUESTIONS

Live@ 3pm

PART-1

Kanisth sir

Work done between the state 1 and 2 in a flow process is given by which one of the following expressions ?

(a) $-\int_1^2 v\,dp$

(b) $\int_1^2 p\,dv$

(c) $\int_1^2 v\,dp + \int_1^2 p\,dv$

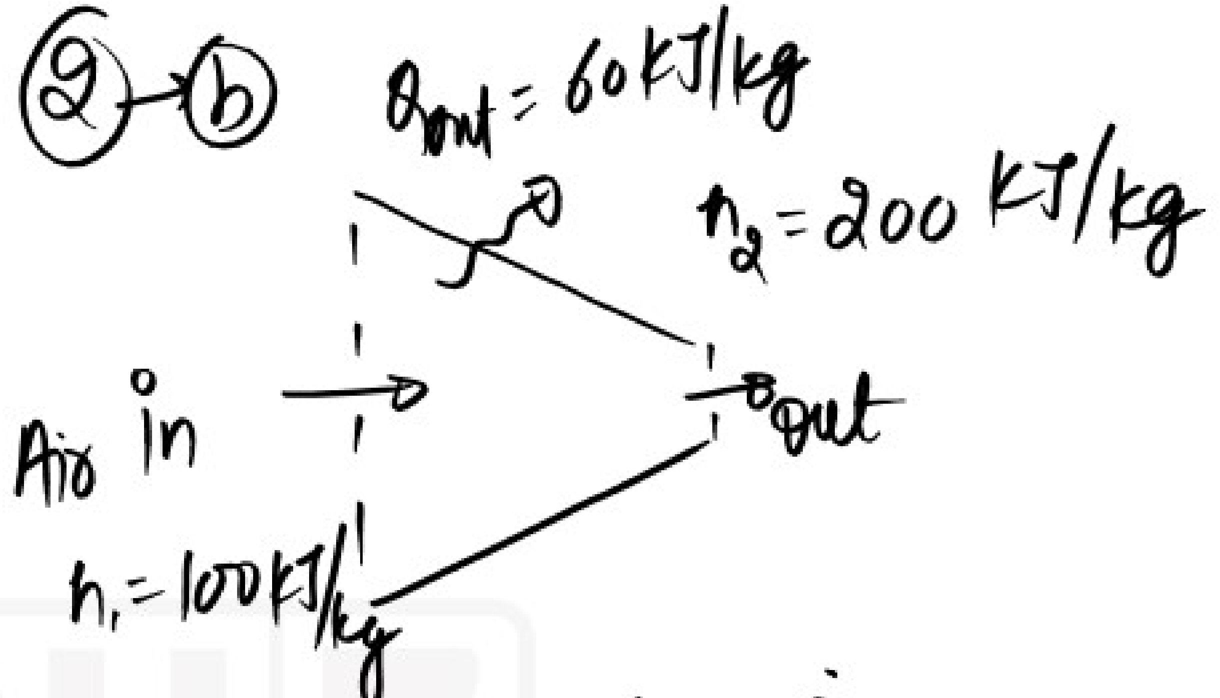
(d) $\int_1^2 v\,dp - \int_1^2 p\,dv$

[CSE-Pre : 2009]

1 → a

An air compressor compresses air with an enthalpy of 100 kJ/ kg to a pressure and temperature that have an enthalpy of 200 kJ/kg. There is 60 kJ/kg of heat lost from the compressor as the air passes through it. Neglecting kinetic and potential energies, what is the power required for an air mass flow of 1 kg/s? (CSE-PRE)

(a) 60 kW
(b) 160 kW
(c) 260 kW
(d) 360 kW



SFEE ⇒ $\dot{E}_{in} = \dot{E}_{out}$

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}(h_1) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out} h_2$

$W_c = Q_{out} + h_2 - h_1 \Rightarrow 60 + (200-100)$

$= 160\ kW$

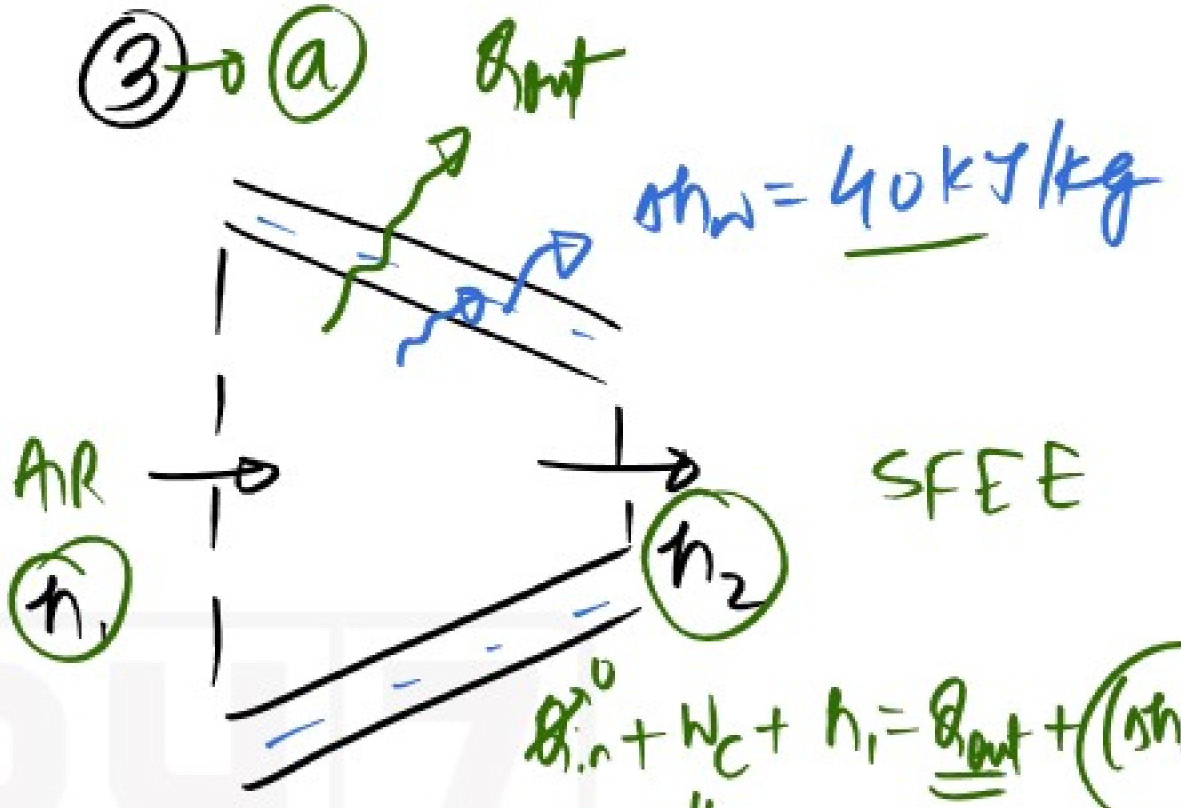
In a test of a water-jacketed compressor, the shaft work required is 90 kN-m/kg of air compressed. During compression, increase in enthalpy of air is 30 kJ/kg of air and increase in enthalpy of circulating cooling water is 40 kJ/kg of air. The change in velocity is negligible. The amount of heat lost to the atmosphere from the compressor per kg of air is

(a) 20 kJ ✓ (b) 60 kJ

(c) 80 kJ (d) 120 kJ

[CSE-Pre : 2000]

(③ → ⓐ)



SFEE

$W_c = 90$ kN-m/kg

$h_2 - h_1 = 30$ kJ/kg

$\cancel{Q_{in}}^{0} + W_c + h_1 = Q_{out} + (\Delta h_w) + h_2$

$90 = Q_{out} + 40 + (h_2 - h_1)$

$Q_{out} = 90 - 40 - 30$

$= 20$

Air enters an adiabatic nozzle at 300 kPa, 500 K with a velocity of 10 m/s. It leaves the nozzle at 100 kPa with a velocity of 180 m/s. The inlet area is 80 cm^2. The specific heat of air c_p is 1008 J/kg K.

2.29 The exit temperature of the air is

[2 Marks]

(A) 516 K (B) 532 K

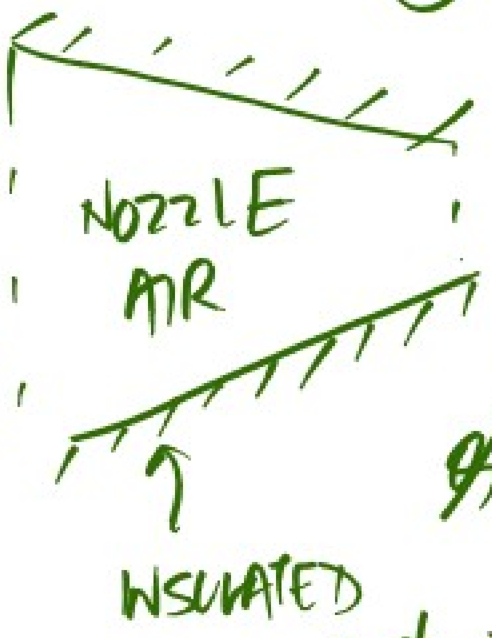
(C) 484 K (D) 468 K

2.30 The exit area of the nozzle in cm^2 is

[2 Marks]

(A) 90.1 (B) 56.3

(C) 4.4 (D) 12.9



In a steady state steady flow process taking place in a device with single inlet and a single outlet, the work done per unit mass.

Flow rate is given by $W = -\int_{inlet}^{Outlet} v dp,$

where v is the specific volume and p is the pressure. The expression for W given above **[2 Marks]**

(A) is valid only if the process is both reversible and adiabatic.

(B) is valid only if the process is both reversible and isothermal.

(C) is valid for any reversible process.

(D) is incorrect it must be

$$W = -\int_{inlet}^{Outlet} p dv.$$

6 → C

The first law of thermodynamics takes the form $W = -\Delta H$ when applied to

[1 Mark]

(A) a closed system undergoing a reversible adiabatic process.

(B) an open system undergoing an adiabatic and potential energies.

(C) a closed system undergoing a reversible constant volume process.

(D) a closed system undergoing a reversible constant pressure process.

8 → b

$\delta Q = dU + \delta W$

$\delta W = -dU$

SFEE

$\dot{E}_{in} = \dot{E}_{out}$

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}\left(h_1 + \frac{V_1^2}{2} + gz_1\right) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}\left(h_2 + \frac{V_2^2}{2} + gz_2\right)$

& KE changes → neglected

$\delta Q = dU + \delta W$

$\delta W = P\,dV = 0$

$\delta W = P(V_2 - V_1)$

$H_1 - H_2 = (W_{out} - W_{in})$

$-(H_2 - H_1) = W_{net}$

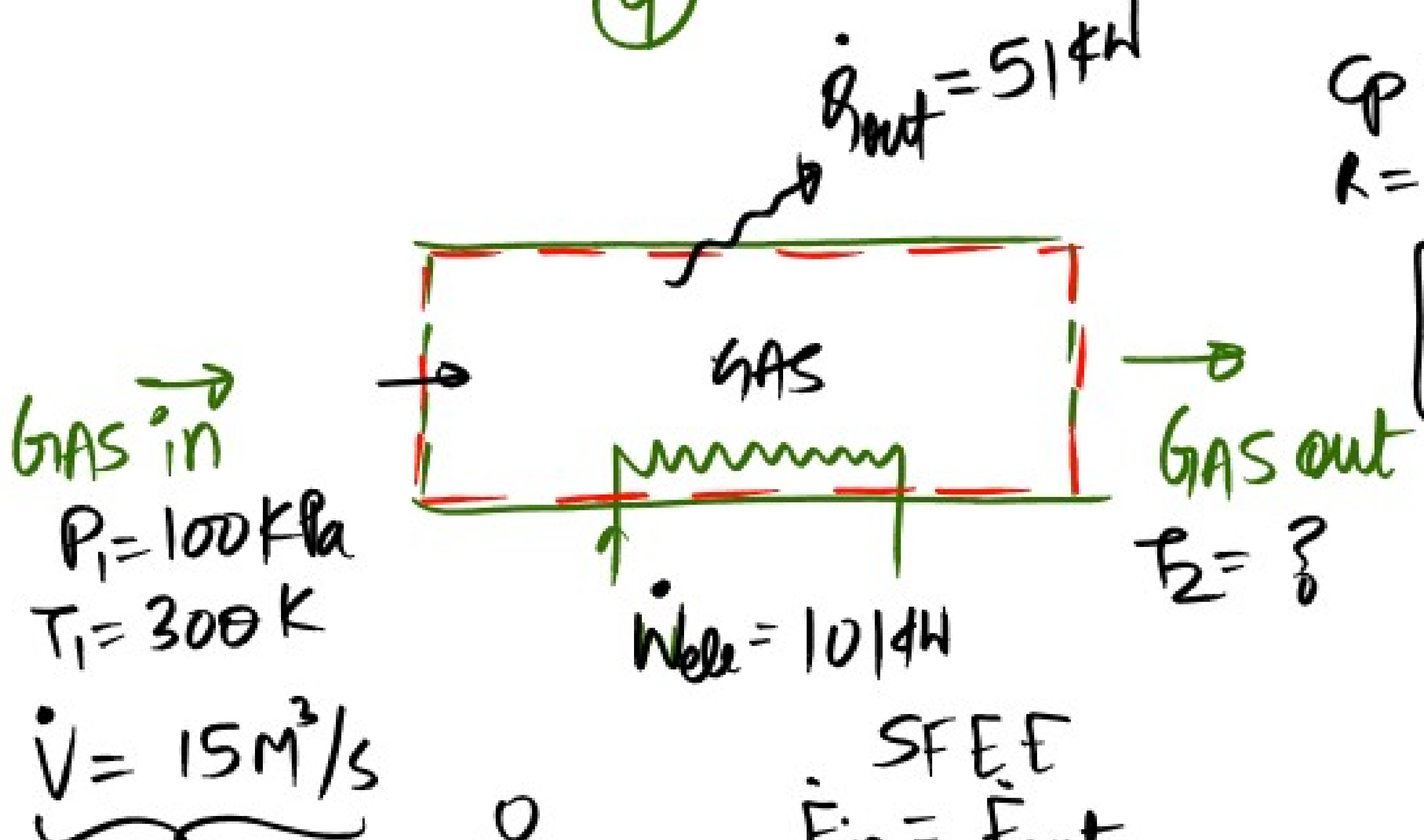
$-\Delta H = W_{net}$

A Gas is heated in a duct as it flows over resistance heater. Consider a 101 kW electric heating system. The gas enters the heating section of the duct at 100 kPa and 27 ^{0}C with a volume flow rate of 15 m^3/s. If heat is lost from the gas in the duct to the surroundings at a rate of 51 kW, the exit temperature of the gas is (Assume constant pressure, ideal gas negligible change in kinetic and potential energies and constant specific heat : $c_p = 1$ kJ/kg K, $R = 0.5$ kJ/kg K)

[2 Marks]

(A) 53 ^{0}C
(B) 37 ^{0}C
(C) 76 ^{0}C
(D) 32 ^{0}C

9



$C_p = 1$ kJ/kg K
$R = 0.5$ ″

$\dot{m}_{in} = \dot{m}_{out} = \dot{m}$

SFEE
$\dot{E}_{in} = \dot{E}_{out}$

$P_1\dot{V} = \dot{m}_1 R T_1$

$\dot{Q}_{in} + \dot{W}_{in} + \dot{m}_{in}\left(h_1 + \frac{V_1^2}{2} + gz_1\right) = \dot{Q}_{out} + \dot{W}_{out} + \dot{m}_{out}\left(h_2 + \frac{V_2^2}{2} + gz_2\right)$

$\dot{m} = \frac{100 \times 15}{0.5 \times 300} = 10$

$101 + \dot{m}h_1 = 51 + \dot{m}h_2$

$\dot{m} = 10$ kg/s

$50 = \dot{m}C_p(T_2 - T_1) \Rightarrow 50 = 10 \times 1(T_2 - 27)$

$T_2 = 32^\circ C$

For a gas, pressure p, volume v and temperature T are dependent on each other. Then which one of the following p -v -T relationship will be obeyed?

(10)

(a) $\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial v}{\partial T}\right)_p \left(\frac{\partial v}{\partial p}\right)_T = -1$

(b) $\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial T}{\partial v}\right)_p \left(\frac{\partial v}{\partial p}\right)_T = -1$

(c) $\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial v}{\partial T}\right)_p \left(\frac{\partial p}{\partial v}\right)_T = -1$

(d) $\left(\frac{\partial p}{\partial T}\right)_v = \left(\frac{\partial T}{\partial v}\right)_p \left(\frac{\partial p}{\partial v}\right)_T$

$$\left(\frac{\partial p}{\partial v}\right)_T \left(\frac{\partial v}{\partial T}\right)_p \left(\frac{\partial T}{\partial p}\right)_v = -1$$

$$\left(\frac{\partial v}{\partial p}\right)_T \left(\frac{\partial T}{\partial v}\right)_p \left(\frac{\partial p}{\partial T}\right)_v = -1$$

$$\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial T}{\partial v}\right)_p \left(\frac{\partial v}{\partial p}\right)_T = -1$$

Which one of the following is the correct statement? Clapeyron equation is used for

(a) finding specific volume of vapour

(b) finding specific volume of liquid

(c) finding latent heat of vaporization

(d) finding sensible heat

Constant pressure lines in the super-heated region of the Mollier diagram have what type of slope?

(a) A positive slope

(b) A negative slope

(c) Zero slope

(d) May have either positive or negative slopes

In free expansion of a gas between two equilibrium states, the work transfer involved

(11) → (c)

(a) can be calculated by joining the two states on p-v coordinates by any path and estimating the area below

(b) can be calculated by joining the two states by a quasistatic path and then finding the area below

(c) is zero ✓

(d) is equal to heat generated by friction during expansion

Variation of pressure and volume at constant temperature are correlated through

(a) Charle'slaw (b) Boyle's law

(c) Joule's law (d) Gay Lussac's law

(12)

For a non-flow constant pressure process the heat exchange is equal to

(13)

(a) zero

(b) the work done

(c) the change in internal energy

(d) the change in enthalpy ✓

$\delta Q = dU + \delta W$

$= dU + PdV$

$= dU + d(PV)$

$= d(U + PV)$

$\delta Q = dH$

The equation of state :

$$pv = RT\left(1+\frac{B}{v}+\frac{C}{v^2}+\frac{D}{v^3}+\ldots\right),$$

is known as

(a) Van der Waals equation

(b) Benedict-Webb-Rubin equation

(c) Gibbs equation

(d) Virial equation

Which one of the following is the correct expression for change in the internal energy for a small temperature change ΔT for an ideal gas?

(a) $\Delta U = C_v \times \Delta T$ (b) $\Delta U = C_p \times \Delta T$

(c) $\Delta U = \frac{C_p}{C_v} \times \Delta T$ (d) $\Delta U = (C_p - C_v)\Delta T$

15 → a

$\Delta U = C_v \Delta T$

What is the ratio of the slopes of p-v curves for an adiabatic process and an isothermal process?

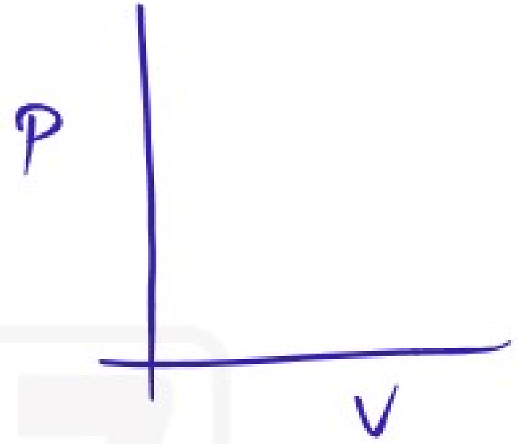
(a) $\frac{1}{\gamma}$

(b) $\gamma + 1$

(c) γ ✓

(d) $\frac{1}{\gamma} + 1$

16 — (c)



$PV = mRT = C$

$PV = C$

$PdV + VdP = 0$

$\frac{dP}{dV} = -\frac{P}{V}$ — (I)

$\frac{dy}{dx} = \frac{dP}{dV}$

$PV^{\gamma} = C$

$\frac{dP}{dV} = -\frac{\gamma P}{V}$ — (II)

(II) / (I)

γ

For a gas that is allowed to expand reversibly and adiabatically, there is no change in

(a) internal energy (b) temperature
(c) entropy ✓ (d) enthalpy

(17) → (c)

REV ✓

ISENTROPIC ✓

ADIABATIC ✓

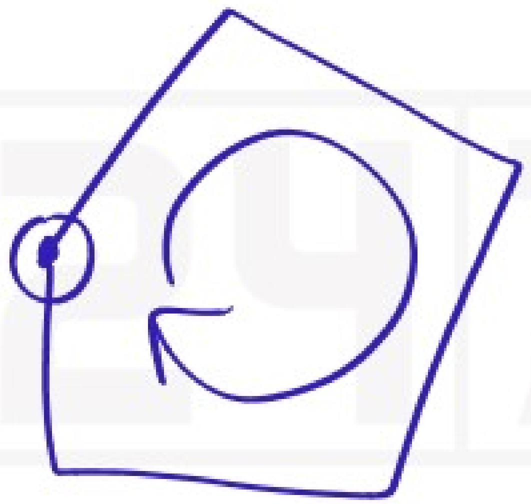
Q. A series of operations, which takes place in a certain order and restore the initial conditions at the end, is known as

(a) Reversible cycle

(b) Irreversible cycle

(c) Thermodynamic cycle

(d) None of these



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Q. A 120 - V electric resistance heater draws 10 A. It operates for 10 min in a rigid volume. Calculate the work done on the air in the volume.

(a) 720000 kJ

(b) 720 kJ ✓

(c) 12000 J

(d) 12 kJ

(19) → (b)

$V = 120\ V$ ✓

$i = 10\ A$ ✓

$t = 10 \times 60 = 600\ sec$ ✓

$W = Vit \Rightarrow 120 \times 10 \times 600 = 720000\ J$

$= 720\ kJ$

Q. Which of the following processes is irreversible process

(a) Isothermal

(b) Adiabatic

(c) Throttling

(d) All of the above

Q. In a reversible adiabatic process the ratio (T_1/T_2) is equal to -

(a) $\left(\frac{p_1}{p_2}\right)^{\frac{\gamma-1}{\gamma}}$ ✓

(b) $\left(\frac{v_1}{v_2}\right)^{\frac{\gamma-1}{\gamma}}$

(c) $(v_1 v_2)^{\frac{\gamma-1}{2\gamma}}$

(d) $\left(\frac{v_2}{v_1}\right)^{\gamma}$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

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

21 → a

Q. In the polytropic process equation $\mathrm{PV}^{n}=$ constant if n is infinitely large, the process is termed as -

(a) Constant volume ✓

(b) Constant pressure

(c) Constant temperature

(d) Adiabatic

(22) → (a)

$PV^n = C$

$V = \frac{C}{(P)^{1/n}}$

$V = C$

Q. Internal energy of system containing perfect gas depends on

(a) Pressure only

(b) Temperature only

(c) Pressure and temperature

(d) Pressure temperature and specific heat

Q. Which of the following equations is incorrect? (where V,P,T and Q are volume, pressure, temperature and heat transfer respectively)

(a) $\oint dV = 0$

(b) $\oint dP = 0$

(c) $\oint dT = 0$

(d) $\oint dQ = 0$

Q. A polytropic process with n = –1, initiates with P = V = 0 and ends with P = 600 kPa and V = 0.01 m3. The work done is

(a) 2 kJ

(b) 3 kJ

(c) 4 kJ

(d) 6 kJ

Q. For an ideal gas, enthalpy is represented by

(a) $H = U - RT$

(b) $H = U + RT$

(c) $H = RT - U$

(d) $H = -(U + RT)$

Q. Certain quantities cannot be located on the graph by a point but are given by the area under the curve corresponding to the process. These quantities in concepts of thermodynamics are called as

(a) cyclic functions

(b) point functions

(c) path functions

(d) real functions

SUN → OFF

MONDAY → 3PM

OPEN SYSTEM
②