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ALWAYS DO
YOUR BEST,
WHAT YOU
PLANT NOW
YOU WILL
HARVEST LATER

QUESTIONS
⇓
CSE PRE
ESE PRE
GATE
PSUs
AE/JE

PYQs

CONCEPTs → SIMPLIFIED WAY ⇓ ADDA 247 ** ⇓ 3 HRS

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

2 to 3 HRS

ISRO | BHEL | DRDO & OTHER PSUs

GATE

Thermodynamics

{Closed system Analysis}

MOST EXPECTED QUESTIONS

Live@ 3pm

Kanisth sir

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Q.1 A 2 kg of steam occupying 0.3 m^3 at 15 bar is expanded according to the law $PV^{1.3}$ = constant to a pressure of 1.5 bar. The work done during the expansion will be

(a) 602.9 kJ
(b) 606.7 kJ
(c) 612.45 kJ
(d) 618.3 kJ

[ESE : 2019]

(1)

$P_1 V_1^{1.3} = P_2 V_2^{1.3}$

$V_2 = \left(\frac{P_1}{P_2}\right)^{\frac{1}{1.3}} V_1$

$$W = \frac{P_1 V_1 - P_2 V_2}{n - 1}$$

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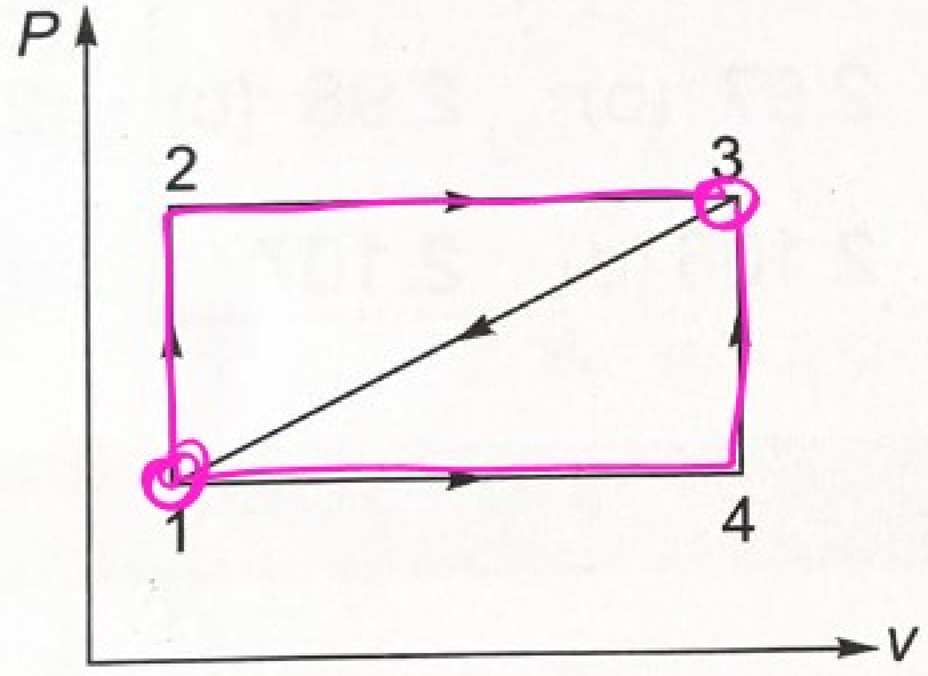
A system absorbs 100 kJ as heat and does 60 kJ work along the path 1–2–3. The same system does 20 kJ work along the path 1–4–3. The heat absorbed during the path 1–4–3 is



(a) – 140 kJ (b) – 80 kJ
(c) 80 kJ (d) 60 kJ

[ESE : 2018]

(2) → (d)

1-2-3

$Q_{1-2-3} = U_3 - U_1 + W_{1-2-3}$

$100 = U_3 - U_1 + 60$

$U_3 - U_1 = 40$ — (1)

1-4-3

$Q_{1-4-3} = U_3 - U_1 + W_{1-4-3}$

$= 40 + 20 = \underline{60 \text{ kJ}}$

$Q_{1-2-3} = +100$

$W_{1-2-3} = +60$

$W_{1-4-3} = +20$

$Q_{1-4-3} = ?$

A thermodynamic cycle is composed of four processes. The heat added and the work done in each process are as follows:

Process	Heat transfer (J)	Work done (J)
1–2	0	+50 (by the gas)
2–3	50 (from the gas)	0
3–4	0	- 20 (on the gas)
4–1	80 (to the gas)	0

The thermal efficiency of the cycle is

(a) 20.3%
(b) 37.5%
(c) 40.3%
(d) 62.5%

[ESE : 2018]

③ – (b) 37.5%

$\eta = \frac{(W_{o/p})_{net}}{Q_s}$

$= \frac{30}{80}$ 37

$+50 - 20 = W_{net}$

30

Statement (I) : First law of thermodynamics analyses the problem quantitatively whereas second law of thermodynamics analyses the problem qualitatively.

Statement (II) : Throttling process is reversible process. [ESE : 2016]

⇓ INCORRECT.

(4)

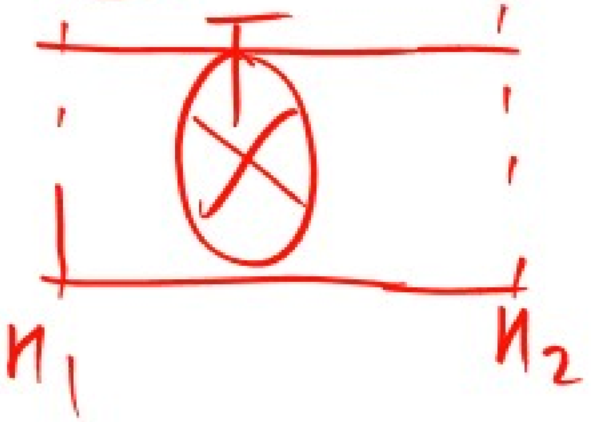
THROTTLING
⇓
FRICTION
⇓
IRREVERSIBLE

In a cyclic process, the heat transfer are +30 J, –50 J and –10 J and +60 J. The network for the cyclic process is

(a) 30 Nm (b) 40 Nm

(c) 50 Nm (d) 60 Nm

[ESE : 2014]



An insulated container is divided into two compartments A and B by a thin diaphragm. While A contains a mass of gas at pressure P and temperature T, B is evacuated. The diaphragm is punctured and the gas in A rushes into B. The process is called

(a) adiabatic
(b) isentropic
(c) constant internal energy
(d) free expansion [ESE : 2013]

6 → d

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Joule's experiment states that for a cycle

(7)

(a) change of pressure is proportional to temperature change

(b) change of volume is proportional to temperature change

(c) change of internal energy is proportional to temperature change

(d) sum of all heat transfer is proportional to sum of all work transfer

[ESE : 2013]

If the work done on a closed system is 20 kJ/kg, and 40 kJ/kg heat is rejected from the system, its internal energy decreases by

(a) 20 kJ/kg (b) 60 kJ/kg

(c) –20 kJ/kg (d) –60 kJ/kg

[ESE : 2012]

8 → a

$\delta Q = dU + \delta W$

$-40 = dU - 20$

$dU = -20$

$U_2 - U_1 = -20$

Codes:

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is not the correct explanation of A

(c) A is true but R is false ✓

(d) A is false but R is true

9 — c

Assertion (A): The change in heat and work cannot be expressed as difference between the end states.

Reason (R): Heat and work both are exact differentials. ↳ INCORRECT

[ESE : 1999]

Q. 170 kJ of heat is supplied to a system at constant volume. Then the system rejects 180 kJ of heat at constant pressure and 40 kJ of work is done on it. The system is finally brought to its original state by adiabatic process. If the initial value of internal energy is 100 kJ, then which one of the following statements is correct?

(a) ✓ The highest value of internal energy occurs at the end of the constant volume process

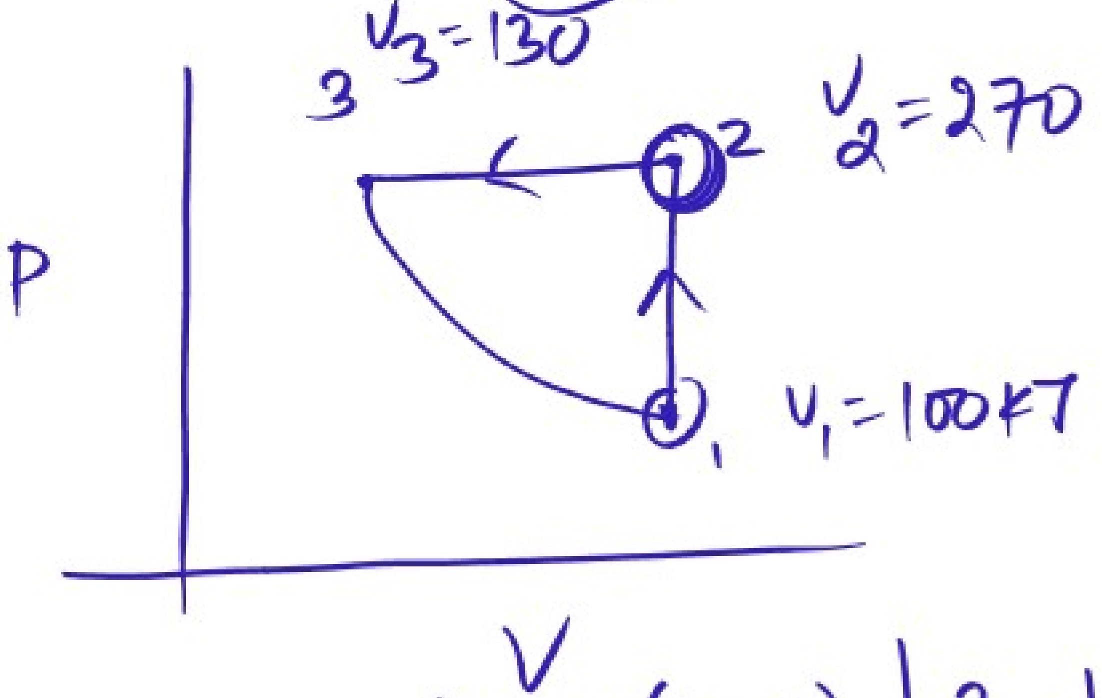
(b) The highest value of internal energy occurs at the end of constant pressure process

(c) The highest value of internal energy occurs after adiabatic expansion

(d) Internal energy is equal at all points

[ESE : 2004]

10



1–2 (V = C)

$Q_{1-2} = +170$

$Q_{1-2} = U_2 - U_1 + W_{1-2}$ ($W_{1-2} = 0$)

$170 = U_2 - 100$

$U_2 = 270$ kJ

2–3 (P = C)

$Q_{2-3} = -180$

$W_{2-3} = -40$ kJ

$Q_{2-3} = U_3 - U_2 + W_{2-3}$

$-180 = U_3 - 270 - 40$

$310 - 180 = U_3$

$130 = U_3$

3–1

$Q_{3-1} = 0$

$W_{3-1} =$

Which one of the following phenomenon occurs when gas in a piston-in-cylinder assembly expands reversibly at constant pressure?

(a) Heat is added to the gas ✓

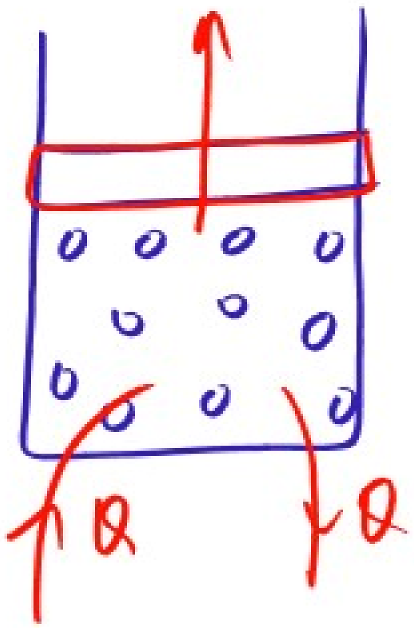
(b) Heat is removed from the gas

(c) Gas does work from its own stored energy ✗

(d) Gas undergoes adiabatic expansion ✗

[ESE : 2003]

(11) → (a)



A perfect gas at 27°C was heated until its volume was doubled using the following three different processes separately:

1. Constant pressure process
2. Isothermal process
3. Isentropic process

Which one of the following is the correct sequence in the order of increasing value of the final temperature of the gas reached by using the above three different processes?

(a) 1 – 2 – 3 (b) 2 – 3 – 1

(c) 3 – 2 – 1 (d) 3 – 1 – 2

[ESE : 2004]

PERFECT GAS

$T_1 = 300\,K$

$V_2 = 2V_1$

$T_2 = ?$

(1) $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$T_2 = \frac{V_2}{V_1} \times T_1$

$= 2 \times 300 = 600\,K$

(2) $T_2 = T_1 = 300\,K$

(12)

(3) $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1} \Rightarrow T_2 = 300\left(\frac{1}{2}\right)^{\gamma - 1}$

5 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I

A. Work done in a polytropic process

B. Work done in steady flow process

C. Heat transfer in a reversible adiabatic process

D. Work done in an isentropic process

List-II

1. $-\int V dp$

2. Zero

3. $\frac{p_1V_1 - p_2V_2}{\gamma - 1}$

4. $\frac{p_1V_1 - p_2V_2}{n - 1}$

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	1	4	2	3
(c)	4	1	2	3
(d)	1	2	3	4

[ESE : 1996]

(13)

(d) 1 2 3 4

A → 4
B → 1
C → 2
D → 3

A non flow quasi-static (reversible) process occurs for which

$P = (-3\ V + 16)$ bar,

where V is volume in m^3. What is work done when V changes from 2 to 6 m^3?

(a) 16×10^5 J ✓ (b) 16.5×10^5 J

(c) 16×10^3 J (d) 16.5×10^2 J

[ESE : 2013]

(14)

$W_b = \int_1^2 P\,dV$

$= \int_1^2 (-3V+16)\times 10^5\,dV$

$= \left(-\frac{3V^2}{2} + 16V\right)\times 10^5 \Big|_2^6$

$\left[-\frac{3}{2}(6^2-2^2) + 16(6-2)\right]\times 10^5$

$-48 + 64$

$= 16\times 10^5$

The volume and temperature of air (assumed to be an ideal gas) in a closed vessel is 2.87 m^3 and 300 K, respectively. The gauge pressure indicated by a manometer fitted to the wall of the vessel is 0.5 bar. If the gas constant of air is $R = 287\ \text{J/kg K}$ and the atmospheric pressure is 1 bar, the mass of air (in kg) in the vessel is **[2 Marks]**

(A) 1.67 (B) 3.33

(C) 5.00 (D) 6.66

(15)

$PV = mRT$

$V = 2.87\ m^3$

$T = 300\ K$

$(P_g = 0.5\ \text{bar},\ P_{atm} = 1\ \text{bar})$

$R = 287\ \text{J/kgK}$

$m = ?$

$1.5 \times 100 \times 2.87 = m \times 0.287 \times 300$

$m = 5\ \text{kg}$

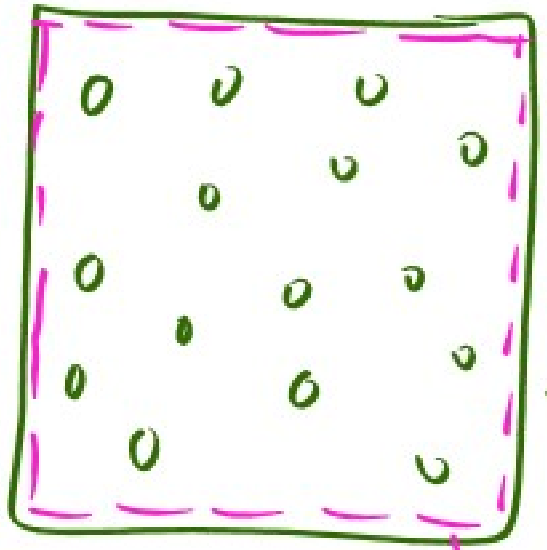
Q. A 4-m 5-m 6-m room is to be heated by a baseboard resistance heater. It is desired that the resistance heater be able to raise the air temperature in the room from 7 to 23°C within 15 min. Assuming no heat losses from the room and an atmospheric pressure of 100 kPa, determine the required power of the resistance heater. Assume constant specific heats at room temperature.

H.W.

(16)

Q. A 3-m3 rigid tank contains hydrogen at 250 kPa and 550 K. The gas is now cooled until its temperature drops to 350 K. Determine (a) the final pressure in the tank and (b) the amount of heat transfer

(17) C_p, C_v, R ***



V = CONSTANT

V = 3 M3

$P_1 = 250 \text{ kPa} \rightarrow P_2$

$T_1 = 550 K \rightarrow T_2 = 350 K$

$P_1 V_1 = mRT_1$

$\frac{250 \times 3}{550 \times (\ )} = m$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$P_2 = \frac{T_2}{T_1} \times P_1 = \frac{350}{550} \times 250 \Rightarrow 159.0 \text{ kPa}$

$\delta Q = dU + \delta W$

$\delta Q = dU + PdV$ → 0

$= mC_v \Delta T \Rightarrow$

$R = \frac{\bar{R}}{M} = \frac{8.314}{1} \Rightarrow$

$C_v = \frac{R}{\gamma - 1} = \frac{(\ )}{1.667 - 1}$

A cylinder contains $5 m^3$ of an ideal gas at a pressure of 1 bar. This gas is compressed in a reversible isothermal process till its pressure increases to 5 bar. The work in kJ required for this process is **[1 Mark]**

(A) 804.7 (B) 953.2

(B) 981.7 (D) 1012.2

The contents of a well-insulated tank are heated by a resistor of 23 Ω in which 10 A current is flowing. Consider the tank along with its contents as a thermodynamic system. The work done by the system and the heat transfer to the system are positive. The rate of heat (Q), work (W) and change in internal energy (ΔU) during the process kW are

[1 Mark]

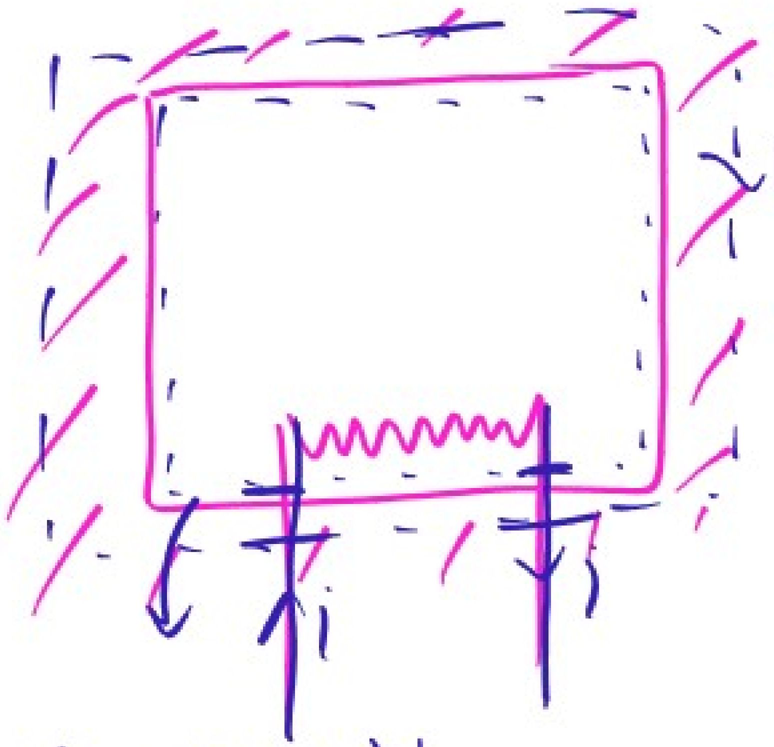
(A) $Q = 0$, $W = -2.3$, $\Delta U = +2.3$ ✓

(B) $Q = +2.3$, $W = 0$, $\Delta U = +2.3$

(C) $Q = -2.3$, $W = 0$, $\Delta U = -2.3$

(D) $Q = 0$, $W = +2.3$, $\Delta U = -2.3$

18



$Q = \Delta U + W$

$0 = \Delta U - 2.3$

$\Delta U = 2.3$

$W = Vit$

$= i^2 R t$

$\frac{W}{t} = i^2 R$

$= 100 \times 23$

$= 2300 \ \frac{J}{s}$

$= 2.3$

In an adiabatic process 6000 J of work performed on a system. In the nonadiabatic process by which the system returns to its original state. 1000 J of heat is added to the system. What is the work done during nonadiabatic process?

(a) +7000 J
(b) –7000 J
(c) +5000 J
(d) –5000 J

[CSE-Pre : 2004]

(19)

$-6000 = W_{1-2}$

$0 = Q_{1-2}$

$? = W_{2-1}$

$1000 = Q_{2-1}$

$Q_{1-2} + Q_{2-1} = W_{1-2} + W_{2-1}$

$0 + 1000 = -6000 + W_{2-1}$

$W_{2-1} = 7000 J$

Which one of the following is the correct statement? Steam is said to be superheated when the

(a) actual volume is greater than volume of saturated steam
(b) actual volume is less than volume of saturated steam
(c) actual volume is equal to volume of saturated steam
(d) None of the above

Which one of the following properties remains unchanged for a real gas during Joule—Thomson process?

(a) Temperature
(b) Enthalpy
(c) Entropy
(d) Pressure

If h, p, T and v refer to enthalpy, pressure, temperature and specific volume respectively; and subscripts g and f refer to saturation conditions of vapour and liquid respectively, then Clausius-Clapeyron equation applied to change of phase from liquid to vapour states is

(a) $\frac{dp}{dt} = \frac{(h_g - h_f)}{(v_g - v_f)}$ (b) $\frac{dp}{dt} = \frac{(h_g - h_f)}{T(v_g - v_f)}$

(c) $\frac{dp}{dt} = \frac{(h_g - h_f)}{T}$ (d) $\frac{dp}{dt} = \frac{(h_g - h_f)T}{(h_g - h_f)}$

For an ideal gas, the expression

$$\left[T\left(\frac{\partial s}{\partial T}\right)_p - T\left(\frac{\partial s}{\partial T}\right)_v\right]$$ is equal to

(a) zero
(b) C_p / C_v
(c) R
(d) RT

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?

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

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

(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

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

(a) zero

(b) the work done

(c) the change in internal energy

(d) the change in enthalpy

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) $\Delta U = (C_p - C_v)\Delta T$

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

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

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

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

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

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

(a) Constant volume

(b) Constant pressure

(c) Constant temperature

(d) Adiabatic

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) $H = -(U + RT)$

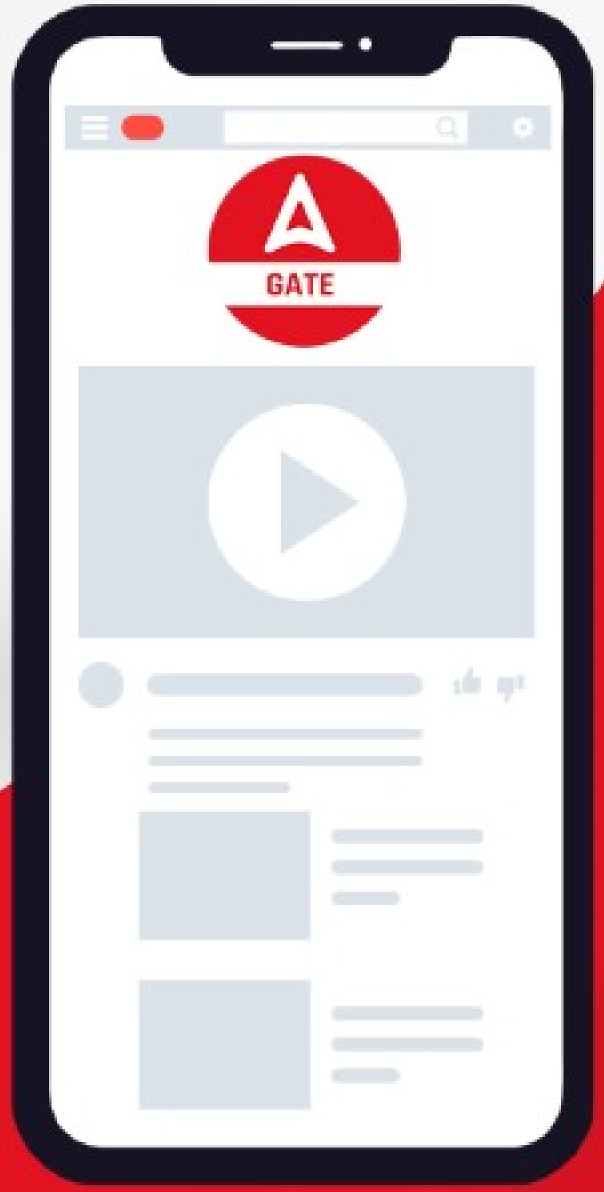
Q. Certain quantities cannot be located on the graph by a point but are given by the area under the curve corresponding to the process. These quantities in concepts of thermodynamics are called as

(a) cyclic functions

(b) point functions

(c) path functions

(d) real functions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