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MECHANICAL ENGINEERING

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

3 HRS

ISRO | BHEL | DRDO & OTHER PSUs

GATE

Thermodynamics

Pure Substance

MOST EXPECTED QUESTIONS

Live@ 3pm

PART-3

Kanisth sir

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Which one of the following represents the condensation of a mixture of saturated liquid and saturated vapour on the enthalpy-entropy diagram?

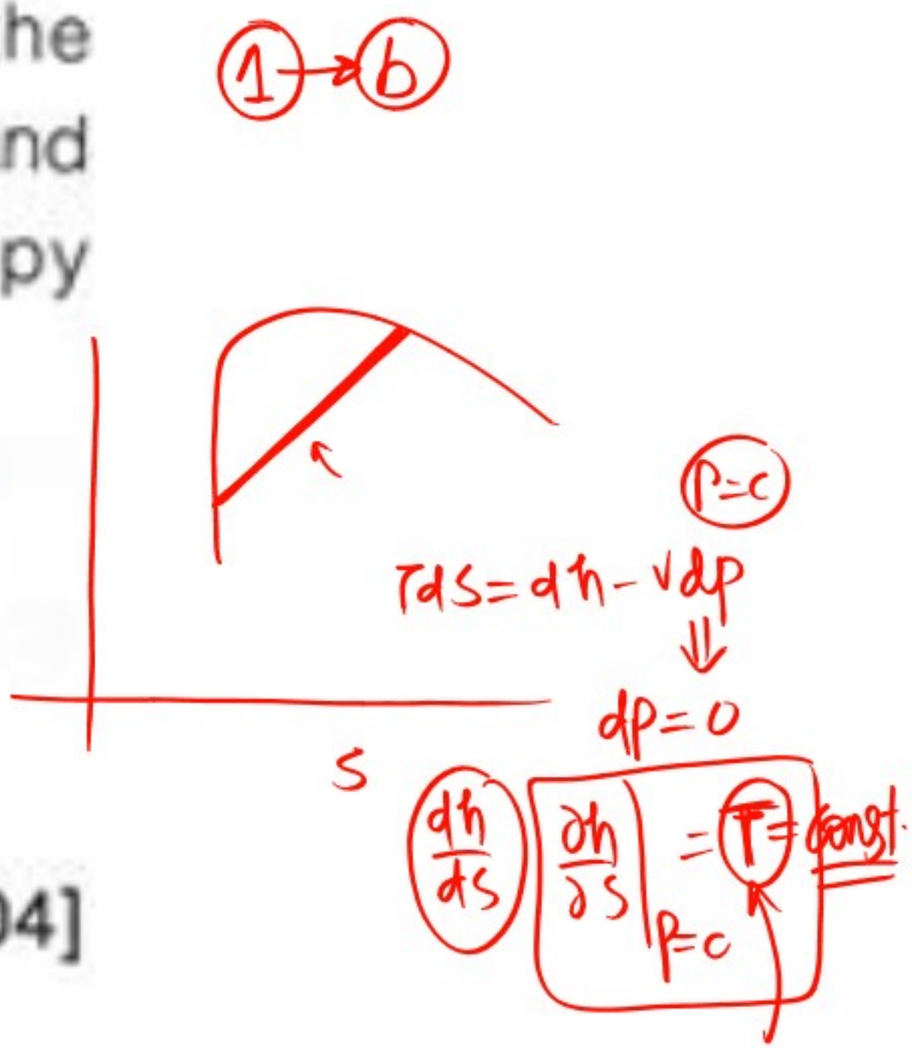
(a) A horizontal line ✗

(b) An inclined line of constant slope ✓

(c) A vertical line ✗

(d) A curved line ✗

[ESE : 2004]



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

List-I	List-II
A. Critical point	1. All the three phases solid, liquid and vapour co-exists in equilibrium
B. Sublimation	2. Phase change from solid to liquid
C. Triple point	3. Properties of saturated liquid and saturated vapour are identical
D. Melting	4. Heating process where solid gets directly transformed to gaseous phase

Codes:

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

[ESE : 2005]

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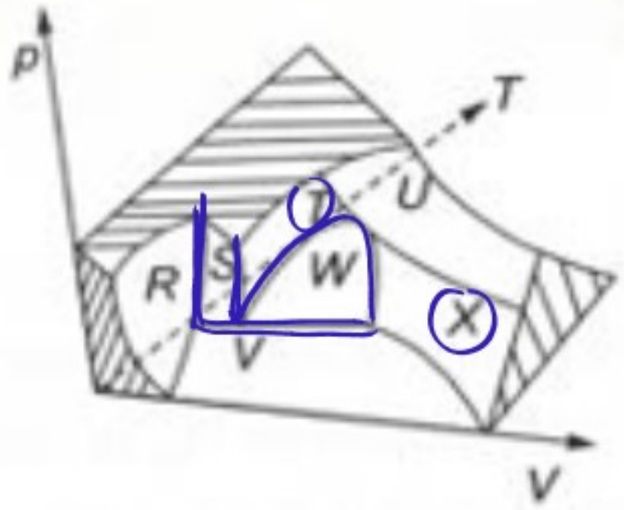
The *p-V-T* surface of a pure substance is shown in the given figure. The two phase regions are labelled as



(a) *R*, *T* and *X*
(b) *S*, *U* and *W*
(c) *S*, *W* and *V*
(d) *R*, *T* and *V*

[ESE : 1999]

PK NAG
CENGEL

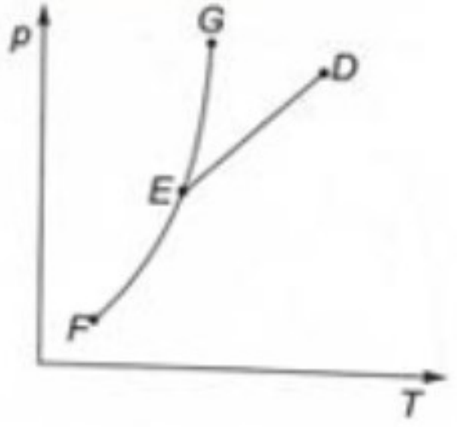
P V T

3

C

P, T, P, V, T V

Consider the phase diagram of a certain substance as shown in the given figure. Match **List-I** (Process) with **List-II** (Curves/lines) and select the correct answer using the codes given below the lists:



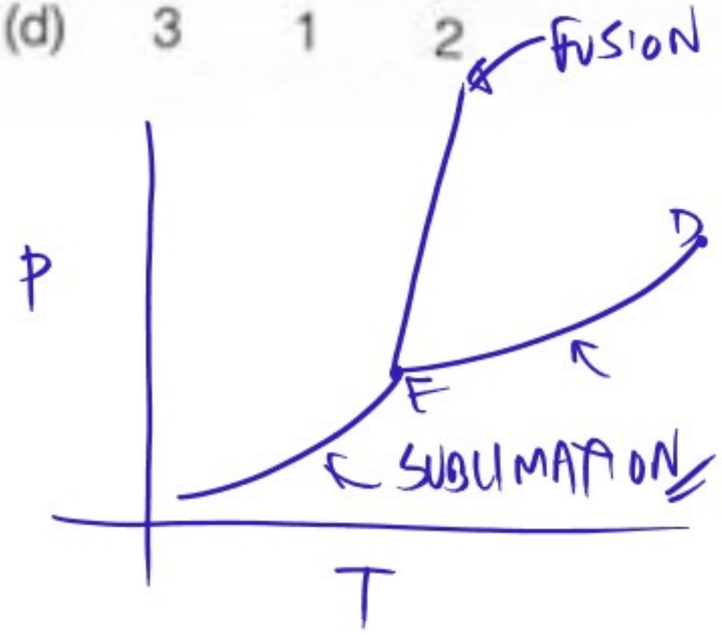
List-I	List-II
A. Vaporization	1. *EF*
B. Fusion	2. *EG*
C. Sublimation	3. *ED*

Codes:

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

④

[ESE : 2001]



A → ED
B → EG
C → EF

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In which one of the following working substances, does the relation $T_2/T_1 = (p_2/p_1)^{0.286}$ hold if the process takes place with zero heat transfer?

(a) Wet steam ✗

(b) Isentropic

(c) Petrol vapour and air mixture ✗

(d) Air ✓

[ESE : 2000]

(5)

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

$\gamma \rightarrow 1.4$ (DIATOMIC O_2, N_2, Air)

$\frac{1.4-1}{1.4} \rightarrow 0.286$

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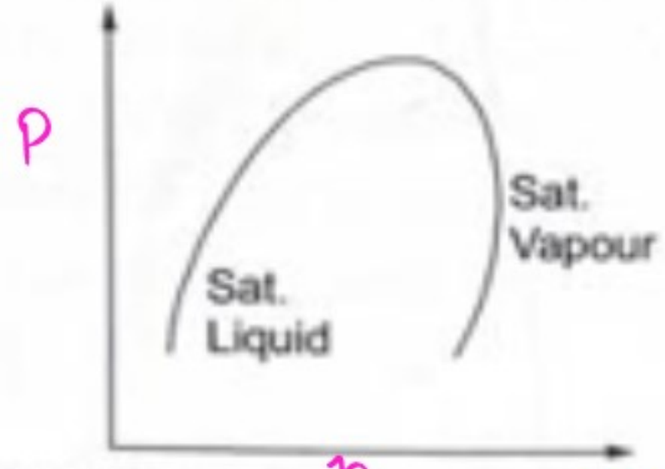
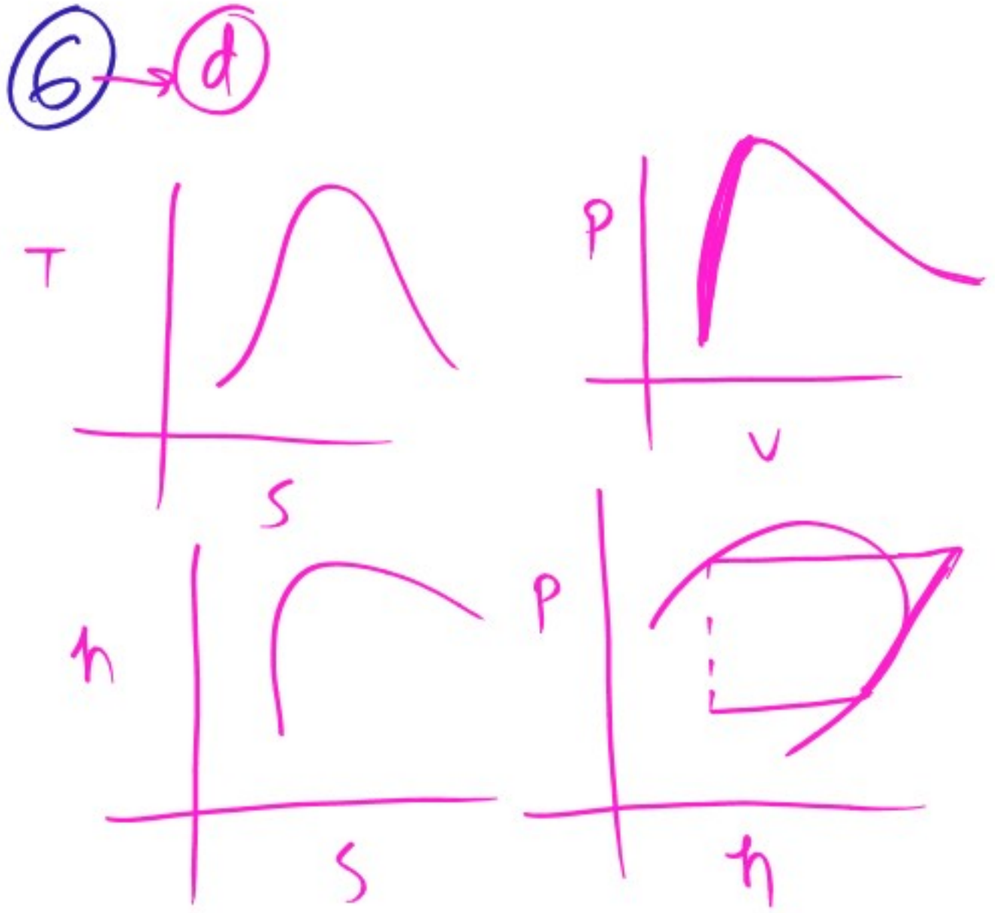
The ordinate and abscissa in the given figure showing the saturated liquid and vapour regions of a pure substance represent



(a) temperature and pressure
(b) enthalpy and entropy
(c) pressure and volume
(d) pressure and enthalpy

[ESE : 1997]



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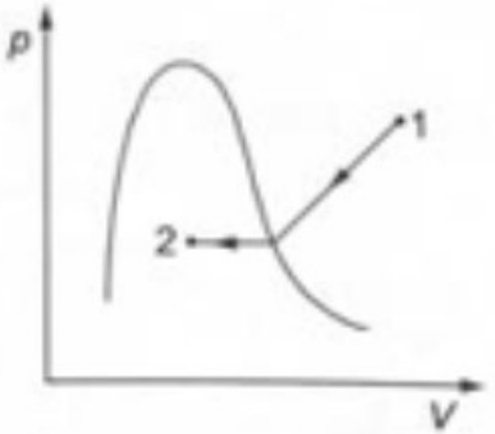
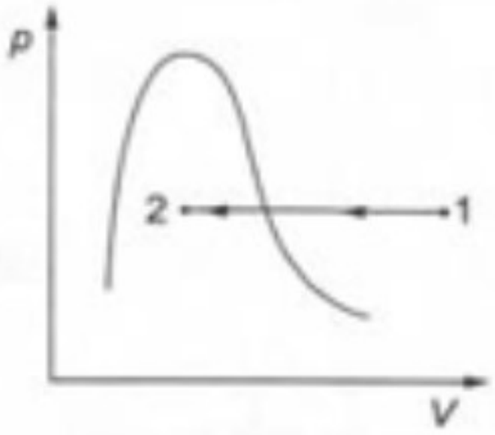
Which one of the following p-V diagrams for steam illustrates the isothermal process undergone by superheated steam till it becomes wet?

(7)

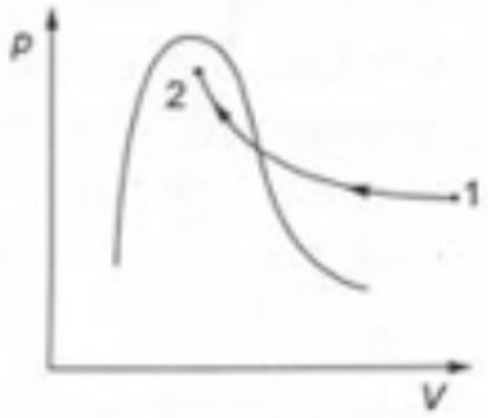
(a)



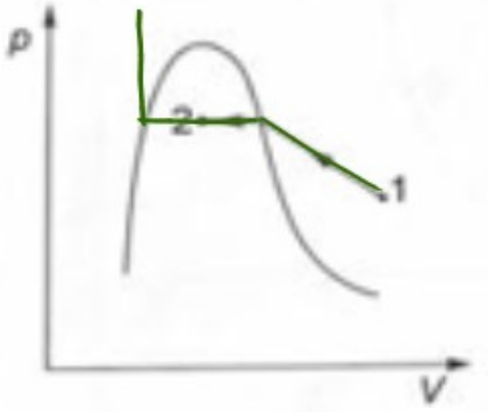
(b)



(c)



(d)



Ans d

[ESE : 1995]

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The given diagram shows the throttling process of a pure substance.

The ordinate and abscissa are respectively

(a) pressure and volume
(b) enthalpy and entropy
(c) temperature and entropy
(d) pressure and enthalpy [ESE : 1995]

(8) → (d)

THROTTLING PROCESS
→ IRREVERSIBLE

$h_1 = h_2$

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The volumetric air content of a tyre at 27°C and at 2 bars is 30 litres. If one morning, the temperature dips to –3°C, then the air pressure in the tyre would be

(a) 1.8 bars ✓
(b) 1.1 bars
(c) 0.8 bars
(d) the same as at 27°C

[CSE-Pre : 2000]

(9) → (a)

$T_1 = 27 + 273 = 300\,K$

$P_1 = 200\,kPa$

$V_1 = 30 \times 10^{-3}\,m^3$

$T_2 = -3 + 273 = 270\,K$

$P_2 = ?$

$V = C =$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{200}{300} = \frac{P_2}{270}$$

$180\,kPa = P_2$

$1.8\,bar$

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One kg of a perfect gas is compressed from pressure p_1 to pressure p_2 by

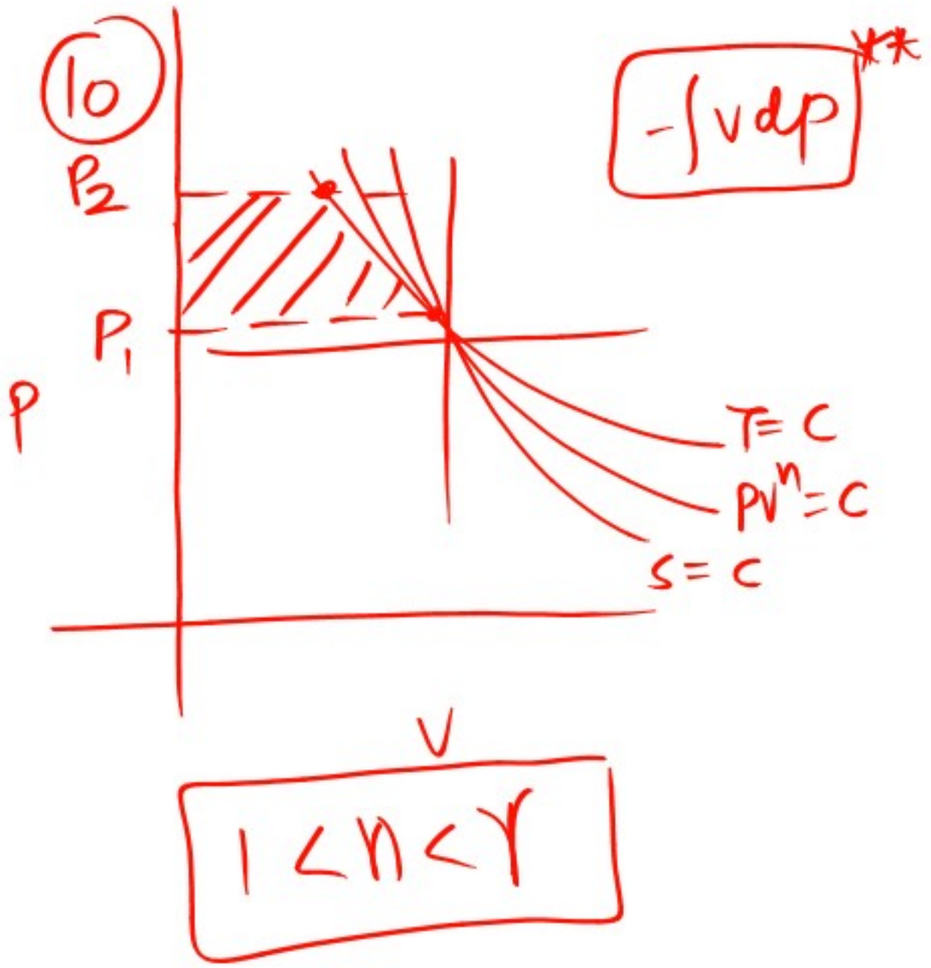
1. isothermal process
2. adiabatic process
3. the law $pv^{1.1}$ = constant

The correct sequence of these processes in increasing order of their work requirement is

(a) 1, 2, 3 (b) 1, 3, 2 ✓

(c) 2, 3, 1 (d) 3, 1, 2

[CSE-Pre : 2000]



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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

[CSE-Pre : 2001]

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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

[CSE-Pre : 2003]

(12)

$\delta Q = dU + PdV$

$= dU + d(PV)$

$= d(U+PV)$

$= dH$

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Which one of the following relationships defines Gibb's free energy G?

(a) $G = H + TS$ (b) $G = H - TS$

(c) $G = U + TS$ (d) $G = U - TS$

[CSE-Pre : 2007]

13 → b

GIBB'S FN. → H - TS

HELMHOLTZ FN → U - TS

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Triple point temperature of water is

(a) 273 K (b) 273.14 K

(c) 273.15 K (d) 273.16 K ✓

[CSE-Pre : 2000] ✓

(14)

TRIPLE POINT

⇓

F=0

WATER { T = .01°C, P =

CRITICAL POINT

0.01°C = t

↳

273.15 + .01

= 273.16

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A rigid container of volume $0.5\ m^3$ contains 1.0 kg of water at 120^0C ($v_f = 0.00106\ m^3/kg$, $v_g = 0.8908\ m^3/kg$).

The state of water is **[1 Mark]**

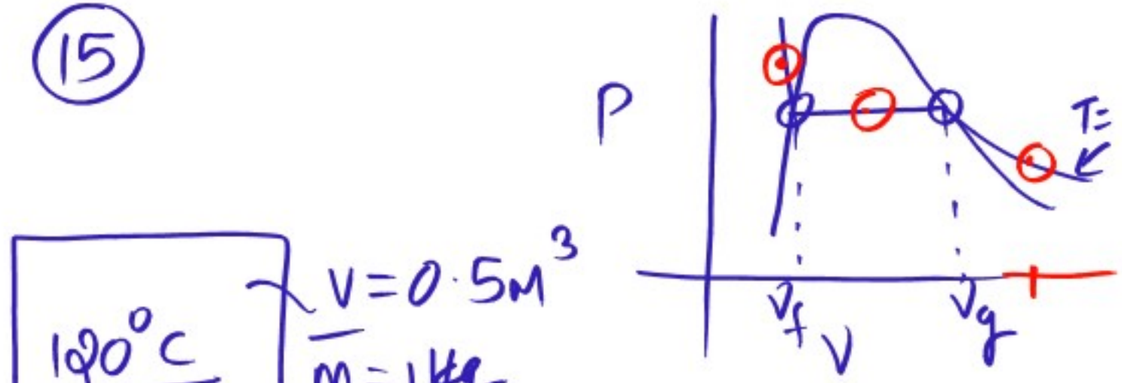
(A) Compressed liquid

(B) Saturated liquid

(C) A mixture of saturated liquid and saturated vapor

(D) Superheated vapor

(15)



120^0C

$V = 0.5 m^3$

$m = 1 kg$

$v = \frac{0.5}{1} = 0.5\ m^3/kg$

$v_f < v < v_g$

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The INCORRECT statement about the characteristics of critical point of a pure substance is that **[1 Mark]**

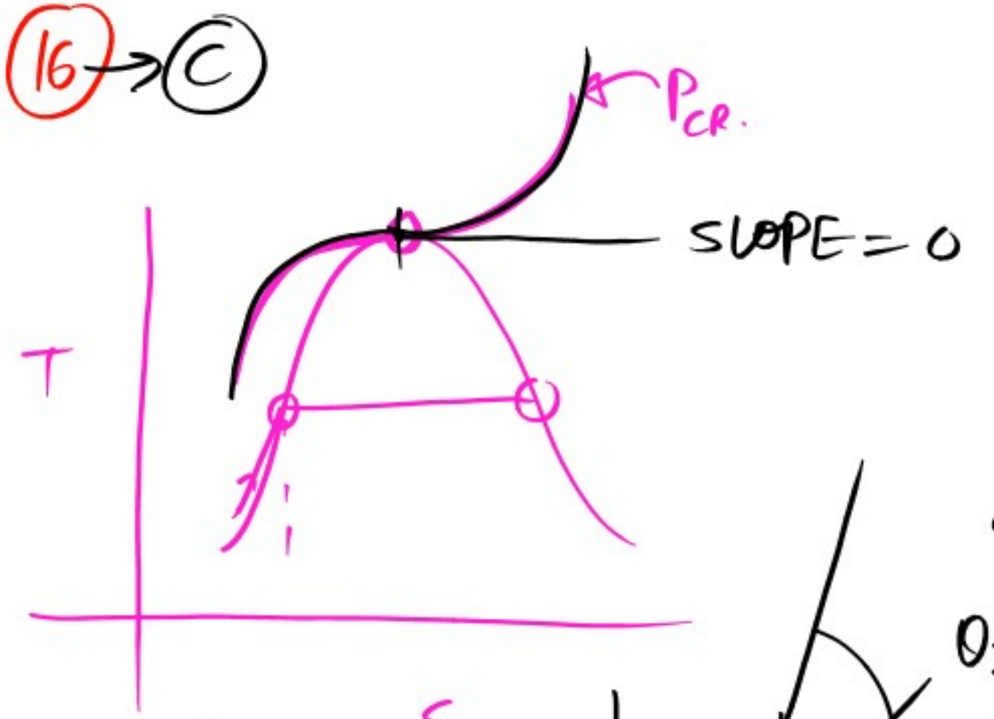
(A) There is no constant temperature vaporization process

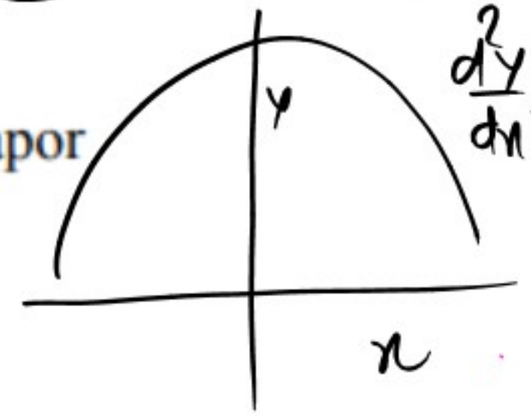
(B) It has point of inflection with zero slope

(C) The ice directly converts from solid phase to vapor phase

(D) Saturated liquid and saturated vapor states are identical

16 → C





$\theta_2 > \theta_1$

$x_2 > x_1$

$\frac{d^2y}{dx^2} > 0$

$\frac{\theta_2 - \theta_1}{x_2 - x_1} > 0$

$\frac{d}{dx}\left(\frac{dy}{dx}\right)$

$\frac{d\theta}{dx} > 0$

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(17)

The molar specifie heat at constant volume of an ideal gas is equal to 2.5 times the universal gas constant (8.314 J/mol K). When the temperature increases by 100 K, the change in molar specific enthalpy is _____ J/mol. **[1 Mark]**

$$\bar{C}_p - \bar{C}_v = \bar{R}$$

$$\bar{C}_p = \bar{R} + \bar{C}_v$$

$\Delta h =$

$\Delta H = m C_p \Delta T$ (MASS BASIS)

$\Delta h = C_p \Delta T$ (

$\bar{\Delta h} = \bar{C}_p \Delta T$

$= (\bar{R} + \bar{C}_v) \Delta T$

$= (\bar{R} + 2.5\bar{R}) 100$

$= 3.5 \times 8.314 \times 100$

$= 2909.9$

ESE → 4 & 5

PSUs → 1✓ MARKED

GATE → 1

CSE PRE

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Steam enters an adiabatic turbine operating at steady state with an enthalpy of 3251.0 kJ/kg and leaves as a saturated mixture at 15 kPa with quality (dryness fraction) 0.9. The enthalpies of the saturated liquid and vapour at 15 kPa are : $h_f = 225.94\,\text{kJ/kg}$ and $h_g = 2598.3\,\text{kJ/kg}$ respectively. The mass flow rate of stream is 10 kg/s. Kinetics and potential energy changes are negligible. The power output of the turbine in MW is

[2 Marks]

(A) 6.5 (B) 8.9

(C) 9.1 (D) 27.0

(18)

SFEE

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

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

$\dot{m}(h_1 - h_2) = \dot{W}_{out}$

$10\left\{3251.0 - \{225.94 + 0.9(2598.3 - 225.94)\}\right\}$

$\Rightarrow$

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