Level - 01

Thermodynamics
Medical 14-15

1. Work done in cyclic process = Area under the graph

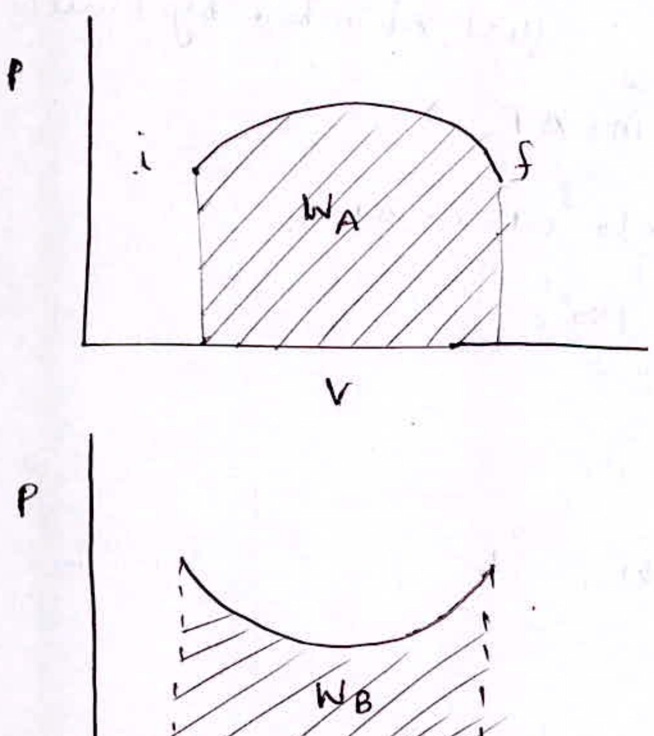
Work = P × V = PV (+ Work, clockwise)

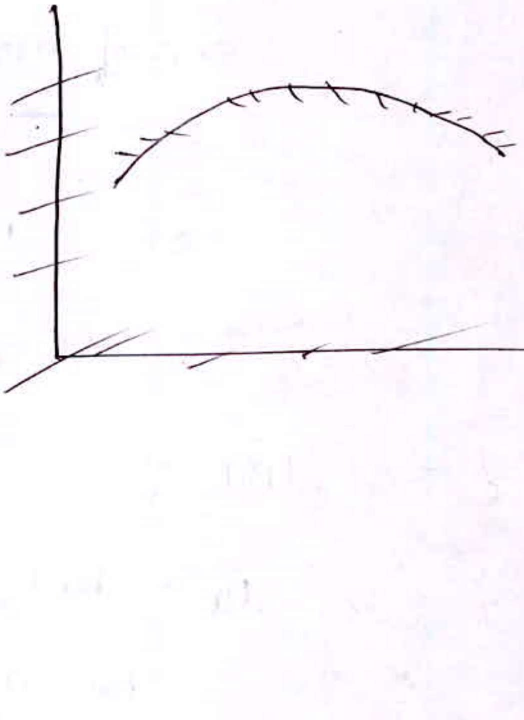
2. ΔQ = ~~du~~ ΔU + ΔW

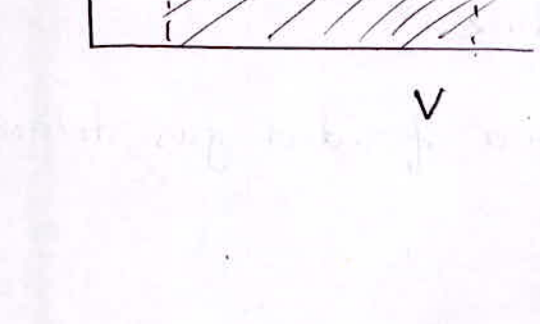
Internal energy is function of state only, so change in internal energy is same but work done in process A is more because Same volume expansion is done at higher pressure, or you can just see the

$$\Delta W = \int_{V_1}^{V_2} p\,dV$$ work by Area under the graph

$$\Delta Q_A > \Delta Q_B$$







3. Work = Area inside the triangle

$= \frac{1}{2} \times (7P_1 - P_1) \times (4V_1 - V_1)$

$= 9 P_1 V_1$

(+) because cycle is clockwise.

4. $\cancel{m}gh = \cancel{m} c \Delta T$ $\left(C = 1 \, \text{cal}/\text{gm}^\circ\text{c} \right.$

$= \frac{1 \times 4.2 \text{ joule}}{10^{-3} \text{ K}}$

MKS unit

$10 \times 100 = \left(\frac{1 \times 4.2}{10^{-3}} \right) \times \Delta T$

$\Delta T = \frac{1}{4.2} = 0.23^\circ C$

5. Total heat $= \frac{1}{2} \times 10 \times 10^{-3} \times (300)^2 = \frac{1}{2} mv^2$

$= 450$ Joule

50% of heat = Heat Absorbed by bullet

$225 = m s \Delta T$

$225 = 10 \times 10^{-3} \times 150 \times \Delta T$

$\Delta T = 150^\circ c$

6. (B)

7. $dQ = du + dw$

$dw = 0$

$dQ < 0$ so $du < 0$

So the temperature of ideal gas decreases.

8. a) Isobaric process → constant pressure → $\Delta P = 0$

b) Isochoric process → constant volume → $\int p\,dv = 0 \; (dv = 0)$

so $\Delta W = 0$

c) Isothermal process → constant T → $\Delta T = 0$

Incorrect ✓ d) Isothermal process → $\Delta T = 0$ → so $du = 0$

But $\Delta Q = \Delta U + \Delta W$

$\Delta Q = 0 + \Delta W$

$\Delta Q = \Delta W$

10. Isothermal process

$pV = \text{constant} = K_1$

$$p = \frac{K}{V}$$

$$\text{slope of curve} = \frac{dp}{dV} = -\frac{K}{V^2} = -\frac{1}{V}\overset{P}{\left(\frac{K}{V}\right)} = -\frac{P}{V}$$

Adiabatic process

$pV^\gamma = \text{constant} = K_2$

$$p = \frac{K_2}{V^\gamma}$$

$$\left(\frac{dp}{dV}\right) = -\gamma\frac{K_2}{V^{\gamma+1}} = -\frac{\gamma}{V}\overset{P}{\left(\frac{K_2}{V^\gamma}\right)} = -\gamma\left(\frac{P}{V}\right)$$

$$\frac{\text{slope of Adiabatic process}}{\text{slope of Isothermal process}} = \gamma$$

9. $(\text{Bulk Modulus})_{\text{Isothermal}} = P$

(11) ✓ a) $\Delta Q = \Delta U + \Delta W$

In Adiabatic process

$$\Delta Q = 0$$

$$\Delta U = -\Delta W$$

change in internal energy = work done on the system

b) Isothermal process

$$\Delta U = 0$$

$$\Delta Q = \Delta W$$

c) Isochoric process

$$\Delta W = 0$$

$$\Delta Q = \Delta U$$

(12) $PV^{\gamma} = \text{constant}$ - (Adiabatic process)

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ $\qquad V_2 = \frac{V_1}{8}$

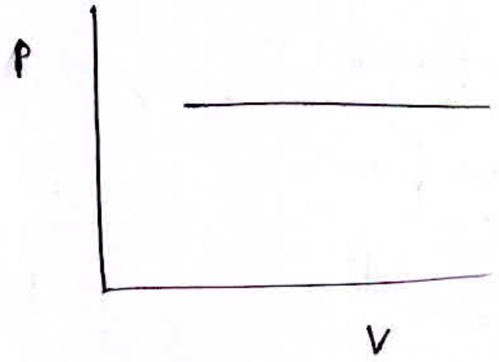
$$P_1 V_1^{\gamma} = P_2 \left(\frac{V_1}{8}\right)^{\gamma}$$

$$P_2 = P_1 (8)^{\gamma}$$

$$= P_1 \times (2^{\cancel{3}})^{\frac{5}{\cancel{3}}}$$

$$= 32 P_1$$

(13)



constant pressure

Isobaric process

(14) Isobaric process

$$Q = nC_p\Delta T$$

$$\Delta U = nC_v\Delta T$$

$$W = Q - \Delta U$$

$$= n(C_p - C_v)\Delta T\cancel{\}}$$

$$= nR\Delta T$$

$$= \left(\frac{1000}{2}\right) \times \left(\frac{8.31}{4.2}\right) \times (20-10)$$

$$= 500 \times 2 \times 10$$

$$= 10^4 \text{ calories}$$

(15)

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

$$= 1.02 \times (3.34 - 2\times10^{-3}) \times 10^5$$

$$= 340 \text{ KJ}$$

(16)

$$\Delta Q = \Delta U + \Delta W$$

$\Delta U = 0$, same state

$$\Delta Q = \Delta W = \text{Area of circle}$$

$$= \pi R^2$$

$$= \pi(10\times\cancel{10^{3}})^2 \text{ KPa-litre}$$

$$= 10^2\pi \text{ KPa-litre}$$

$= \pi\, 10^2$ kpa-litre

$= \pi\, 10^2$ kpa-$\left(\frac{1}{1000}\right) m^3$

$= \pi \times 10^2 \times 10^3 \times \frac{1}{1000}$ p-m^3

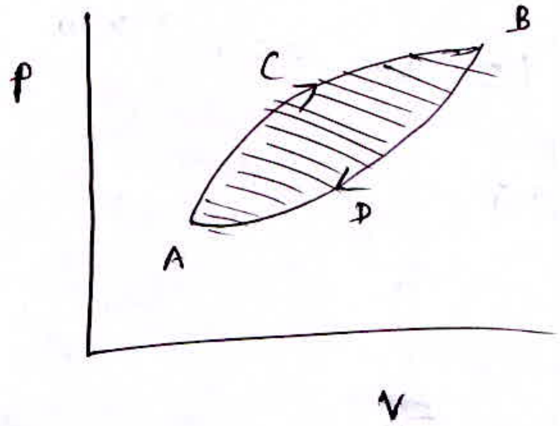
$= \pi \times 10^2 \left(\frac{N}{m^2} \times m^3\right)$

$= \pi \times 10^2$ joule

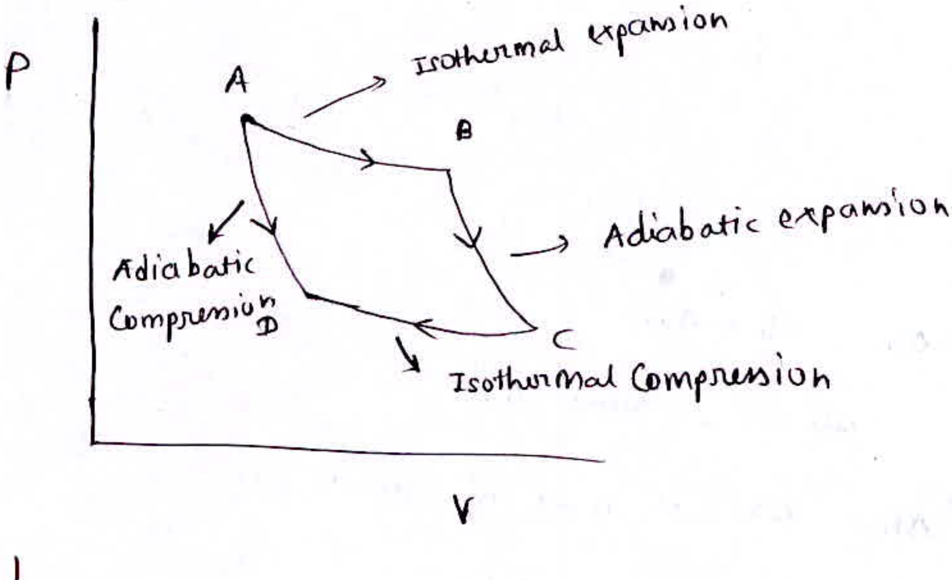
(17) (D)

(18) Net work done = Area Inside the curve

= ACBDA



(19)



(20) (D)

level-02

1. Work = Area Inside cycle

$$= \frac{1}{2} \times 2P_1 \times 2V_1$$

$$= 2P_1V_1$$

2. $\Delta Q = \Delta U + \Delta W$

a) Not necessary, if the process is Isothermal, then all the heat will be used in work done, so ΔU can be zero

b) Internal energy is a function of temperature

$$\Delta U = nC_V \Delta T$$

always increase with increase in temperature

c) $\Delta Q = \Delta U + \Delta W$

$0 = \Delta U + \Delta W$

$\Delta U = -\Delta W$

If ΔW is negative that is work is done on the system then ΔU will increase

d) It does not depend on velocity of vessel

3. $W_{AB} = P(V_2 - V_1) = P_0(V_0 - 2V_0) = -P_0V_0$

$W_{BC} = \int p\,dv = 0 \qquad (dv = 0)$

$W_{CD} = P\cancel{\Delta V}. \int p\,dv = \cdot p \int_{V_0}^{3V_0} dV \qquad [P \text{ constant}]$

$= 2P_0(3V_0 - V_0) = 4P_0V_0$

$W_{ABCD} = -P_0V_0 + 0 + 4P_0V_0 = 3P_0V_0$

4. 50% of Energy = $m s \Delta T$

$$\frac{1}{2} \times \left(\frac{1}{2} \cancel{m} v^2\right) = \cancel{m} \times s \times \Delta T$$

$$\Delta T = \frac{v^2}{4s}$$

5.

$$\cancel{m} g (h_2 - h_1) = \cancel{m} s \Delta T$$

$$\frac{9.8 \times 24.5}{252} = \Delta T$$

$$\Delta T = 0.95 \text{ K}$$

6.

$$Q = m c \Delta T$$

$$4200 \text{ Joules} = \cancel{m \times \left(\frac{4.2}{4.2}\right) \Delta T} = m \times 4.2 \times \Delta T$$

$$m \Delta T = 1000$$ (m in gm)

7.

$$\Delta Q = du + \Delta W$$

$$200 = du + (-100)$$

$$du = 300 \text{J}$$

[W is Negative because work is done on the system)

8.

$$\Delta Q = \Delta U + \Delta W$$

$$-20 = \Delta U + (-8)$$

$$\Delta U = -20 + 8 = -12$$

$$U_f - U_i = -12$$

$$U_f = 30 - 12$$

$$= 18 \text{ J}$$

9. $Q = n C_p \Delta T$

$= n C_p (T_2 - T_1)$

$dW = p\,dv$

$W = \int_{V_1}^{V_2} p\,dV$

$= p \int_{V_1}^{V_2} dV$ { pressure constant }

$= p(V_2 - V_1)$

10. a) At equilibrium pressure on both side will be equal

$$\text{pressure} = \frac{\text{Force Applied by spring at equilibrium}}{\text{Area}}$$

$$= \frac{K x_0}{S}$$

b) Work done by the gas

$$= \int p\,dv$$

$$= \int_0^{x_0} \left(\frac{Kx}{S}\right) \times (S\,dx)$$

$$= \int_0^{x_0} Kx\,dx$$

$$= K\left(\frac{x_0^2}{2}\right)$$

(c) $\Delta Q = du + \Delta W$

chamber is thermally insulated

so $\Delta Q = 0$

$$du = -\Delta W = -\frac{K x_0^2}{2}$$

(d) $du = \frac{-kx_0^2}{2}$

Internal energy decreased so the temperature will also decrease.

$$du = n c_v \Delta T$$

(11). $\Delta Q = du + \Delta W$

$du = 0$, Isothermal process $\Delta T = 0$

$\Delta Q = \Delta W$ [work is done on the system)

$$\Delta Q = -1.5 \times 10^4 \text{ J}$$

$$= \frac{-1.5 \times 10^4}{4.2} \text{ calories}$$

$$= -0.36 \times 10^4 \text{ Calories}$$

$$= -3.6 \times 10^3 \text{ Calories}$$

(A)

(12) Initial Energy $= \frac{f}{2} NRT$ $f = 5$ For diatomic gas

$$= \frac{5}{2} NRT$$

Final Energ $= \frac{3}{2} \times (2n) RT + \frac{5}{2} (N-n) RT$

$$= \cancel{3NRT}\ 3nRT + \frac{5}{2} (N-n) RT$$

Heat supplied to the gas $= \cancel{3NRT - \frac{5}{2} NRT}$

$$= \cancel{\frac{1}{2} NRT}$$

$$= 3nRT + \frac{5}{2} (N-n) RT - \frac{5}{2} NRT$$

$$= 3nRT - \frac{5}{2} nRT = \frac{1}{2} nRT$$

13. $\Delta Q = du + \Delta W$

$0 = -100 + \Delta W$

$\Delta W = 100$

14. $pv^{\gamma} = k$

$p = +kV^{-\gamma}$

$\frac{\Delta P}{P} = -\gamma \frac{\Delta V}{V}$

$\left[y = x^n \quad \frac{\Delta y}{y} = n \frac{\Delta x}{x} \right]$

15. In adiabatic process

$\Delta Q = du + \Delta W$

$\Delta W = -\Delta U$

Internal energy of the gas is used in doing work

16. Adiabatic elasticity $= \frac{dP}{-dV/V} = \gamma P$

$= 1.4 \times 10^5 \ N/m^2$

17. Identical Adiabatic vessels, same volume

$P \propto T$

$dU = n C_v dT$

$U \propto T$

$U \propto P$

$\frac{U_{01}}{U_{02}} = \frac{P_1}{P_2}$

Finaly the temperature will be equal

so Internal energy will be equal

$$U_{f_1} = U_{f_2}$$

18. process is Adiabatic.

$$\Delta Q = 0$$

19.
$$W = \int p\,dv$$

$$= P_{atmosphere} \times \int_{1\,cm^3}^{1671\,cm^3} dv$$

$$= 1.02 \times 10^5 \times 1670 \times (10^{-6}) \text{ N-m}$$

$$= 170.34 \text{ Joule}$$

$$= \frac{170.34}{4.2} \text{ calorie} = 40.55 \text{ cal.}$$

20.
$$\Delta Q = 540 \text{ cal.} = 540 \times 4.2 \text{ J} = 2268 \text{ J}$$

$$\Delta W = 1.01 \times 10^5 \times 1670 \times 10^{-6}$$

$$= \underline{168.67} \cdot \text{Joule}$$

$$= \cancel{\frac{168.67}{4.2}} =$$

$$\Delta U = 2268 - 168.67$$

$$= 2099 \text{ J}$$

21. Internal energy is the state function of temperature only. In cyclic process the system comes to same state. So there is no change in temperature ~~only~~. So $\Delta U = 0$ in all cyclic process

22. $\Delta Q = \Delta U + \Delta W$

$\Delta U = 0$

ΔW = Area under the curve (Elipses)

$= \pi (a)(b)$

$= \pi \times \frac{100}{2} \times 10^{3} \times \frac{40}{2} \times 10^{-6}$

$= \pi$ J

23. Area Inside the close graph

$= \frac{1}{2} \times (2V_0 - V_0) \times (2P_0 - P_0) - \frac{1}{2} \times (2V_0 - V_0)(3P_0 - 2P_0)$

(clockwise) (Anticlockwise)

$= \frac{P_0 V_0}{2} - \frac{P_0 V_0}{2}$

$= 0$

25 (c)

Assertion And Reasons

1. It's An Adiabatic process

$$\Delta Q = 0$$

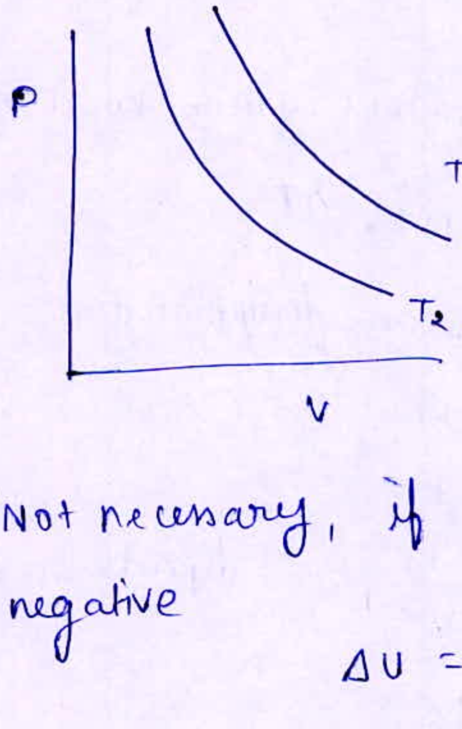
$$\Delta U = -\Delta W$$ (Work is positive, expansion)

Temperature will decrease

2. In thermodynamic process, entropy will ~~some energy will be wasted in non conservative~~ There will be a heat loss, so irreversible

3. Same as (1)

4.



Never intersect

5. – Not necessary, if volume decrease, work is negative

$$\Delta U = -\Delta W$$
$$= +ve$$

Temp. ↑

– Not necessary slow process

6. - All heat converts into work $\Delta U = 0$

- It's correct

7. - No, we can change it, Adiabatic process

-

8. $dQ = mc\,dT$

9. —

10. No. $\Delta Q = \Delta U + \Delta W$

Not necessarily

11. - Energy conservation

- Wrong Higher T ⟶ lower T

12. —

13. Work is done on the system, so Temperature increase

14. $\Delta U = n c_v \Delta T$

depends on temperature

15. $\Delta U = -\Delta W$

$TV^{\gamma-1} = k$

$T = \frac{k}{V^{\gamma-1}}$ depends on volume

16. $ds = \int \frac{dQ}{T}$

$dQ = 0$. in Adiabatic

so $ds = 0$

17. $\Delta Q = \Delta U + \Delta W$ Energy Conservation

Energy = $M^1 L^2 T^{-2}$

M, L, T Are fundamental

18. Zeroth law leads to Concept of temperature

19. $$\eta = 1 - \frac{T_{sink}}{T_{source}}$$

$$\eta = \frac{W}{Q_{in}}$$

20. - wrong highest for gas

- ~~Atoms are~~ Correct

previous year's Questions

1. Work done = Area Inside the curve

$$= \underset{(\text{clockwise})}{\frac{1}{2}(2V_0 - V_0)(2P_0 - P_0)} - \underset{(\text{Anticlockwise})}{\frac{1}{2} \times (3P_0 - 2P_0)(2V_0 - V_0)}$$

$$= 0$$

2. Internal energy does not depend on path of process. It's function of temperature only. P and V are same at A and B so T will also be equal

$$\Delta U_1 = \Delta U_2 = \Delta U_3$$

$$W = \int P\,dV \quad = \text{Area under the graph}$$

$$W_1 > W_2 > W_3$$

$$\Delta Q = dU + \Delta W$$

$$\Delta Q_1 > \Delta Q_2 > \Delta Q_3$$

3. Work = Area Inside the graph

$$= -(3V - V)(2P - P) \qquad \text{[Negative because Anticlockwise)}$$

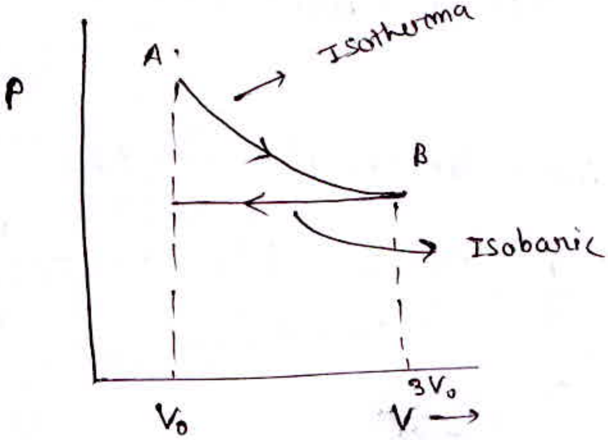
$$dW = -2PV$$

$$\Delta U = 0$$

$$\Delta Q = \Delta U + \Delta W = -2PV$$

Negative means heat is given to the ~~system~~ surrounding by the system.

4. (D)



5. $\Delta Q = n C_p \Delta T$

$310 = 2 \times C_p \times (35-25)$

$C_p = \frac{310}{20} = 15.5 \text{ J/mol-K}$

$C_p = C_v + R$

~~Cv =- Cp- Cv~~ $C_v = C_p - R$

$= 15.5 - 8.31$

$C_v = 7.2 \text{ J/mol-K}$

At Constant volume

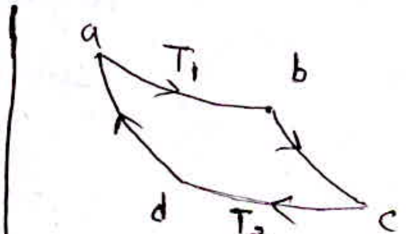
$\Delta Q = n C_v \Delta T$

$= 2 \times 7.2 \times 10$

$= 144$ Joule

6. $W_{ab} + W_{b\to c} + W_{c\to d} + W_{d\to a} > 0$ clockwise cycle

work done in A to B is more positive than Negative work done from C to D. [Area under the graph)



$W_{b\to c}$ ([redacted] =

$W_{b\to c} = -W_{d\to a}$

$W_{b\to c} + W_{d\to a} = 0$

7. $$ds = \int \frac{dQ}{T}$$

$$= \frac{80 \times 1000}{273}$$

$$= 293 \text{ cal/K}$$

8. a) In process AB and CD, heat is given to the system, but temperature is constant, All the heal is being used in changing the state of material

b) —

c) $Q_{AB} = m \times L_f$

$Q_{CD} = m \times L_v$

$Q_{CD} = 2\, Q_{AB}$

$m L_v = 2 \times m L_f$

$L_v = 2 L_f$ (Incorrect option)

d) —

e) $L_v = 2 L_f$

9. Temp . $$\frac{A-72}{110} = \frac{B-72}{220}$$

$$\frac{A-72}{110} = \frac{A-72}{220}$$

$$2A - A = 72^\circ$$

10. (c)

11. process is Isochoric (constant volume)

$$Q = nC_v \Delta T$$

$$= 2 \times \frac{f}{2} R \times \Delta T$$

$$= 2 \times \frac{3}{2} \times 8.31 \times 20$$

$$= 498\ J$$

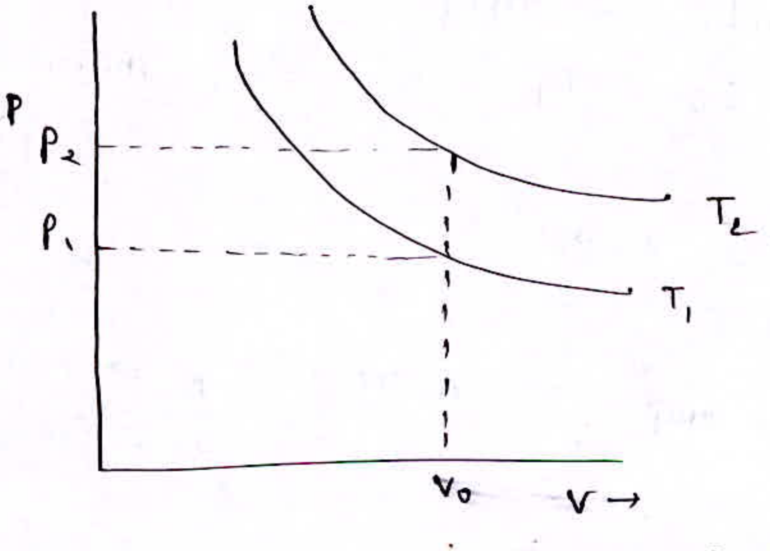
12. Isothermal process

$$W = nRT \ln\left(\frac{V_2}{V_1}\right)$$

$$= 10 \times 8.31 \times 600 \ln\left(\frac{10}{100}\right)$$

= ~~-14.4~~ -11.4×10^4 J

13.



At ~~6~~ volume V_0 for both, pressure is more for T_2 graph.

$P \propto T$ (same volume)

$P_2 > P_1 \rightarrow T_2 > T_1$

14. $\Delta Q = \Delta U + \Delta W$

ΔU will be same for both process.

$8\times10^5 = \Delta U + 6.5\times10^5$

$\Delta U = 1.5\times10^5$ J

$\Delta Q = \Delta U + \Delta W$

$10^5 = 1.5\times10^5 + \Delta W$

$\Delta W = -0.5\times10^5$ J

0.5×10^5 J work is done on the gas.

15. $W = nRT \ln\left(\frac{V_2}{V_1}\right)$

$= RT \ln\left(\frac{V_2}{V_1}\right)$

16. (c)

17. (d)

18. Work = Area under the graph

$\Delta U = 0$ (same state)

$Q = \Delta U + W = 0 + W = W$

19. Initial energy = Final energy

$\frac{5}{2}\times1\times RT_0 + \frac{3}{2}\times1\times R\times\frac{7T_0}{3} = \frac{5}{2}RT_f + \frac{3}{2}RT_f$

$6RT_0 = 4RT$

$T_f = \frac{3}{2}T_0$

20. $\Delta Q = \Delta U + \Delta W$

$\Delta U = 0$ (cyclic process)

$Q_1 + Q_2 + Q_3 + Q_4 = W_1 + W_2 + W_3 + W_4$

$W_4 = 765\ J$

21. No diagram

22. (c)

23. At constant pressure

$\Delta Q = n C_p \Delta T$

$\Delta U = n C_v \Delta T$

$\Delta W = n C_p \Delta T - n C_v \Delta T$

$$\text{Fraction} = \frac{n C_p \Delta T - n C_v \Delta T}{n C_p \Delta T}$$

$$= 1 - \frac{1}{\gamma}$$

24. $\Delta W = P(V_2 - V_1)$ Isobaric

$= 50(4-10)$

$= -300\ J$

$\Delta Q = \Delta U + \Delta W$

$100 = \Delta U - 300$

$\Delta U = 400\ J$

25. (A) Not necessary, In isothermal process temperature remains Constant. All the heat given to the System is used in work.

(B) $W = \int_{V_1}^{V_2} P\,dv$

If W is positive then volume will always increase

26. ~~All~~ Some heat is used to do work and some heat is used to overcome intermolecular forces and becomes it's Internal energy.

$$\Delta Q = \Delta U + \Delta W$$

$$540 \times 4.19 \text{ J} = \Delta U + 1.013 \times 10^5 \times (1671 - 1) \times (10^{-6} m^3)$$

$$\Delta U = \cancel{500}\ 2093.429 \text{ Joule}$$

$$= 500 \text{ calorie}$$

27. a) doesn't change in Isothermal or cyclic process.

b) depends only on state, Both internal energy and Entropy

c) Isoentropic process

d) $\Delta Q = 0, \quad \Delta W = -\Delta U$

28. Volume decreases (Ice → water at 0°)

29. cyclic process, $\Delta U = 0$

$$\Delta Q = \Delta U + \Delta W$$

$$\Delta Q = \Delta W$$

$$\Delta Q_{A-B} + \Delta Q_{B-C} + \Delta Q_{C-A} = \Delta W_{A \to B} + \Delta W_{B \to C} + W_{C-A}$$

$$5 = \underbrace{P(V_2 - V_1)}_{\text{Isobaric}} + \underbrace{0}_{\text{Isochoric}} + W_{C-A}$$

$$5 = 10 \times 1 + W_{C \to A}$$

$$W_{C \to A} = -5 \text{ J}$$

30. work done by conservative force depends on the path.

31. $$\Delta Q = \Delta U + \Delta W$$

$$150 = \Delta U + 110$$

$$\Delta U = 40 \text{ J}$$

32. $$Q_1 + Q_2 + Q_3 + Q_4 = W_1 + W_2 + W_3 + W_4$$

$$x = 1000 - 300 = 700 \text{ J}$$

$$\eta = \frac{1000 \times 100}{9500} = 10.5 \%$$

33. $W = \int P\,dV$

$= 0$ $\quad (dV = 0)$

34. a) Internal energy depends only on the state, function of temperature

b) Isothermal process $\Delta T = 0$, $\Delta U = nC_v\Delta T = 0$

c) Area under p-v graph is work

d) work and heat, both are path dependent.

35. (a)

36. Work = Area

$= (+)\,P \times V$ $\quad (\because$ clockwise cycle$)$

37. $W = \frac{1}{2} \times 2V \times P = PV$

38. $\Delta Q = \Delta U + \Delta W$

$-30 = \Delta U - 10$

$\Delta U = -20$

$U_f - U_i = -20$

$U_f = 40 - 20 = 20\,J$

39. $\Delta Q = \Delta U + \Delta W$

$\Delta U = \Delta Q - \Delta W$ (Not a path function)

40. $\Delta Q = \Delta U + \Delta W$

$40 = \Delta U + 30$

$\Delta U = 10$ J

41. Question from Assertion and Reason

Q.2

42. Isobaric process

$W = P(V_2 - V_1)$

$= 2 \times 10^5 \times (150 - 50) \times 10^{-3}$

$= 2 \times 10^4$ J

1 litre = 1000 ml

$= 1000$ cm^3

$= 1000 \times 10^{-6}$ m^3

$= 10^{-3}$ m^3

43. = 200 X 4.19 Joule

= 838 Joule

44 (c)

45. When temperature of gas Increase, its internal energy always increase.

$$\Delta Q = \Delta U + \Delta W$$

Temperature can also increase if no heat is given to the system

$$\Delta Q = 0 = \Delta U + \Delta W$$

$$\Delta U = -\Delta W$$ (If ΔW is negative, then $\Delta U \uparrow$, $T \uparrow$)

~~46~~ Temperature can also Increase, if no work is done by the gas, All the heat supplied to the gas goes into internal energy, process is Isochoric.

$$\Delta Q = \Delta U + \Delta W$$

$$= \Delta U + 0$$

$$= \Delta U$$

$$\Delta Q \uparrow \longrightarrow \Delta U \uparrow \longrightarrow T \uparrow$$

47. (d)

48. W = Area of Rectangle (+ because clockwise)

$$= 2P \times 2V$$

$$= 4PV$$

4.

49. $\Delta Q = \Delta U + \Delta W$

$110 = 40 + \Delta W$

$\Delta W = 70\ J$

50. Work = Area of Triangle (+ve, clockwise)

$= \frac{1}{2} \times 2V \times 3P$

$= 3PV$

Thermodynamic processes

1. $C_p' - C_v' = R$, when C_p' and C_v' are molar heat capacity

$C_p' - C_v' = R$

For Nitrogen $28 C_p - 28 C_v = R$

$28 (C_p - C_v) = R$

$28 (m) = R$

$m = \frac{R}{28}$

For hydrogen $C_p' - C_v' = R$

$2 C_p - 2 C_v = R$

$C_p - C_v = R/2$

$m = R/2$

$28 m = 2m$

$14 m = m$

2. $\eta = 1 - \frac{T_2}{T_1} = 1 - \left(\frac{127+273}{227+273}\right)$

$= 1 - \frac{400}{500} = 0.2 \Rightarrow 20\%$

$\eta = \frac{\text{work done}}{\text{Heat input}} = 0.2$

work done $= 0.2 \times 6 \times 10^4$

$= 1.2 \times 10^4$ J

3. (b)

4. $\Delta Q = 0$

$\Delta Q = \Delta W + \Delta U$

$\Delta U = - \underset{\searrow \text{positive}}{\Delta W}$

$= \text{Negative}$

Temperature will decreas

~~$PV = nRT$~~ $\qquad PV^{\gamma} = K$

~~$P = \frac{nRT}{V}$~~ $\qquad P = \frac{K}{V^{\gamma}}$

$V \uparrow \quad P \downarrow$

5. $PV^{\gamma} = \text{constant}$

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = \left(\frac{V_1}{V_1/8}\right)^{5/3} = (2^3)^{5/3}$

$= 32$

6. Question from Assertion Reason

Q. 4

8. $PV^{\gamma} = K$

$P = KV^{-\gamma}$

$\frac{\Delta P}{P} = -\gamma \frac{\Delta V}{V} \Rightarrow \frac{\Delta V}{V} = -\frac{2}{3} \times \frac{2}{3} = -\frac{4}{9} \%$

7. $$W_{\text{Adiabatic}} = \frac{nR(T_i - T_f)}{\gamma - 1} =$$

$$-146 \times 10^3 = \frac{1000 \times 8.31 \times (-7)}{\gamma - 1}$$

$$\gamma - 1 = 0.397$$

~~$\gamma = 1.45 = 1 + \frac{2}{f}$~~ $\quad \gamma = 1.397 \approx 1.4$

~~$f = \frac{2}{0.45}$~~ Diatomic

$f =$

9. $$PV^{\gamma} = K$$

$$\frac{nRT}{V} V^{\gamma} = K$$

$$TV^{\gamma-1} = K_1$$

10. $$TV^{\gamma-1} = K$$

$$T = \frac{K}{V^{\gamma-1}}$$

Adiabatic expansion $V \uparrow, T \downarrow$

11. Isothermal

12. (c) $dp = 0$

$$= \frac{dp}{-dv/v}$$

13. $pV^{y} = K$

$$p\left(\frac{nRT}{p}\right)^{y} = K$$

$$p^{1-y}T^{y} = K$$

$$p = \left(\frac{K}{T^{y}}\right)^{\frac{1}{1-y}} = T^{+y\times\frac{1}{(y-1)}} \times K^{1-y}$$

~~y/(y-1)=~~ $\frac{y}{y-1} = 3 \Rightarrow y = 3y - 3$

$$\frac{C_p}{C_v} = y = \frac{3}{2} = 1 + \frac{2}{f}$$

14. Isothermal process $\Delta T = 0$

$du = nC_v \Delta T$

Increase n

15. -

16. Adiabatic $\Delta Q = 0 = \Delta U + \Delta W$

$\Delta U = -\Delta W$

Isothermal $\Delta U = 0$

17.

$$PV^{\gamma} = K$$

$$P\left(\frac{nRT}{P}\right)^{\gamma} = K$$

$$P^{1-\gamma}T^{\gamma} = K_1$$

$$P = K_1 T^{\frac{\gamma}{\gamma-1}}$$

$$c = \frac{\gamma}{\gamma-1} = \frac{5/3}{2/3} = 5/2$$

$$\left[\begin{aligned} \gamma &= 1 + \frac{2}{f} \\ &= 1 + \frac{2}{3} \\ &= 5/3 \end{aligned}\right.$$

monoatomic

18.

Adiabatic process

$$PV^{\gamma} = K$$

$$P\left(\frac{nRT}{P}\right)^{\gamma} = K$$

$$P^{1-\gamma}T^{\gamma} = K_1$$

$$T = K_1^{1/\gamma}(P)^{\frac{-1+\gamma}{\gamma}}$$

$$\frac{T_2}{T_1} = \left(\frac{1}{8}\right)^{\frac{2/3}{5/3}} = (8)^{-2/5}$$

19.

Thermos flask $\Delta Q = 0$

~~Work is done by on the system~~

Mechanical energy given to the system is converted into heat

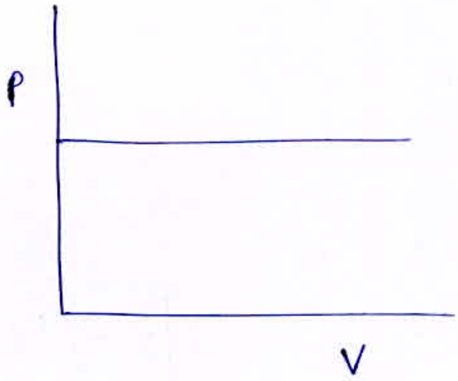
20.

$$PV^{\gamma} = K$$

$$\frac{nRT}{V}(V^{\gamma}) = K$$

$$TV^{1-\gamma} = K_1$$

21.



Isobaric

Constant p

22.

$$ds = \int \frac{dQ}{T}$$

Temperature Constant

$$ds = \frac{1}{T} \int dQ$$

$$dQ = dU + dW$$

$$dQ = 0 + dW = dW$$

$$ds = \frac{1}{T} \int dW = \frac{1}{T} \times nRT \ln \frac{V_2}{V_1}$$

$$= 1 \times R \times \ln \frac{V_2}{V_1}$$

23.

$$W_{Isothermal} = nRT \ln \left(\frac{V_2}{V_1} \right)$$

$$= nRT \ln \left(\frac{V_2}{V_1} \right)$$

24.

Isochoric $\rightarrow$ $dv = 0$

$$\Delta Q = \Delta U + \Delta W$$

$$\Delta Q = \Delta U$$

25. It's Adiabatic expansion

$$PV^\gamma = K$$

$$\frac{nRT}{V} \times V^\gamma = K$$

$$TV^{\gamma-1} = K_1$$

$$T = \frac{K_1}{V^{\gamma-1}}$$

V ↑, so T ↓

26.

$$PV^{3/2} = K$$

$$\frac{nRT}{V} \times V^{3/2} = K$$

$$T\sqrt{V} = K_1$$

$$\frac{T_2}{T_1} = \sqrt{\frac{V_1}{V_2}} = \sqrt{2}$$

$$T_2 = \sqrt{2}\,T_1$$

27.

$$P_1V_1^\gamma = P_2V_2^\gamma$$

$$P_1^{1-\gamma}\,T_1^\gamma = P_2^{1-\gamma}\,T_2^\gamma$$

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

$$t_2 = T_1 \times \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

28. $$W = \frac{n\cancel{R}(T_i - T_f)}{\gamma - 1} = 6\cancel{R}$$

$$T_i - T_f = 6(\gamma - 1)$$

$$T_i - T_f = 6\left(\frac{5}{3} - 1\right)$$

$$T_i - T_f = 10 - 6 = 4$$

$$T_f = T_i - 4 = T - 4$$

29. (c)

30. $$\Delta W = P(V_2 - V_1)$$

$$= 50(4 - 10)$$

$$= -300\ J$$

$$\Delta Q = \Delta U + \Delta W$$

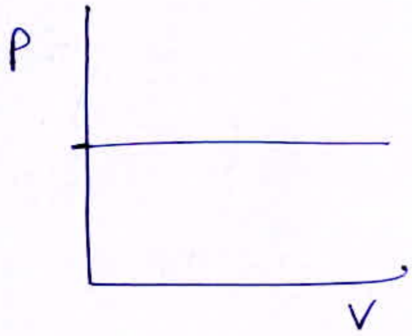
$$100 = \Delta U - 300$$

$$\Delta U = 400\ J$$

31. (B)

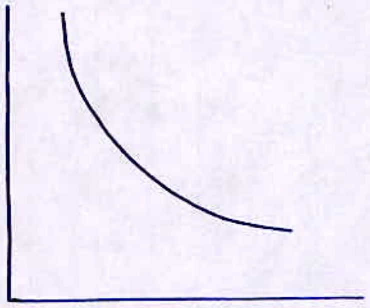
32. constant V

$P \propto T$



33. (A) Atmospheric pressure

34. $p \propto \frac{1}{V}$



35. — Adiabatic process

$$pv^{\gamma} = K$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = \left(\frac{V}{2V}\right)^{\frac{3}{2}} = \frac{1}{2\sqrt{2}}$$

$$P_2 = \frac{1}{2\sqrt{2}} \times 2\sqrt{2}\,P = P$$

— Isobaric process

$$P_1 = P_2 = P$$

— Isothermal process

$$\frac{P_2}{P_1} = \frac{V_1}{V_2} = \frac{1}{2}$$

$$P_2 = \frac{2P}{2} = P$$

$$P : P : P = 1 : 1 : 1$$

36 $\Delta Q = \Delta U + \Delta W$

At constant P, $\Delta Q = nC_P \Delta T$

$$= n(\gamma C_v)\,\Delta T$$

$$= \gamma\,(nC_v \Delta T)$$

$$= \gamma\,\Delta U$$

$$\gamma \Delta U = \Delta U + P(2V - V)$$

$$(\gamma - 1)\Delta U = PV$$

$$\Delta U = \frac{PV}{\gamma - 1}$$

37. $$T \cdot \propto \frac{1}{\sqrt{V}}$$

$$T = \frac{k}{\sqrt{V}}$$

$$TV^{1/2} = k$$

$$\gamma - 1 = \frac{1}{2}$$

$$\gamma = \frac{3}{2}$$

38. $$PV = nRT$$

~~PV.~~ constant pressure

$$V \propto T$$

$$T_1 = 300$$

$$T_2 = 600$$

$$PV_2 = nRT_2$$

$$PV_1 = nRT_1$$

$$W = P(V_2 - V_1) = 0.1 \times R(T_2 - T_1)$$

$$= 0.1 \times 2 \times 300$$

$$= 60 \text{ cal.}$$

Second Law of Thermodynamics

1. $$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{27+273}{127+273}$$

$$= 1 - \frac{300}{400} = \frac{1}{4}$$

$$\frac{\text{Work done by Engine}}{\text{Heat supplied}} = \frac{1}{4}$$

$$\text{work done} = \frac{1}{4} \times 40 = 10 \text{ KJ}$$

2. $$1 - \frac{T_2}{T_1} = \frac{1}{4} = \frac{25}{100}$$

$$\frac{T_2}{T_1} = \frac{3}{4}$$

$$T_1 = \frac{4}{3} T_2 = \frac{4}{3} \times 300 = 400 \text{ K}$$

$$= (400 - 273)^\circ C$$

$$= 127^\circ C$$

3. $$\eta = 1 - \frac{T_2}{T_1}$$

$$\frac{1}{4} = 1 - \frac{T-80}{T}$$

$$\frac{1}{4} = 1 - 1 + \frac{80}{T}$$

$$T = 320 \text{ K}$$

$$= 320 - 273$$

$$T = 47^\circ C$$

Temperature of sink = $T - 80 = 47 - 80 = -33^\circ C$

4. (S1) can't be 1

$$\eta = 1 - \frac{T_2}{T_1} \qquad T_2 \neq 0$$

(S2) $\Delta Q = \Delta U + \Delta W$ Corre

(S3) correct

(S4)

5. a) doesn't change in isothermal

b) correct

(c) ΔS can be zero.

(d) $\Delta Q = \Delta U + \Delta W$

$$\Delta W = -\Delta U$$

6. At normal temperature

$$C_v = \frac{f}{2} R$$

$$C_v = \frac{3}{2} R \qquad f = 3 \quad \text{For monoatomic}$$

as ~~Tem~~ high temperature $f = 3$ For monoatomic

No vibration

No Rotation

$$C_v = \frac{3}{2} R$$

For diatomic →

At Normal Temperature

$f = 5$ (3 translational + 2 Rotational)

$$C_V = \frac{5}{2} R$$

At higher temperature

$f = 7$

$$c_V = \frac{7}{2} R$$

8. $$\eta = 1 - \frac{T_2}{T_1}$$

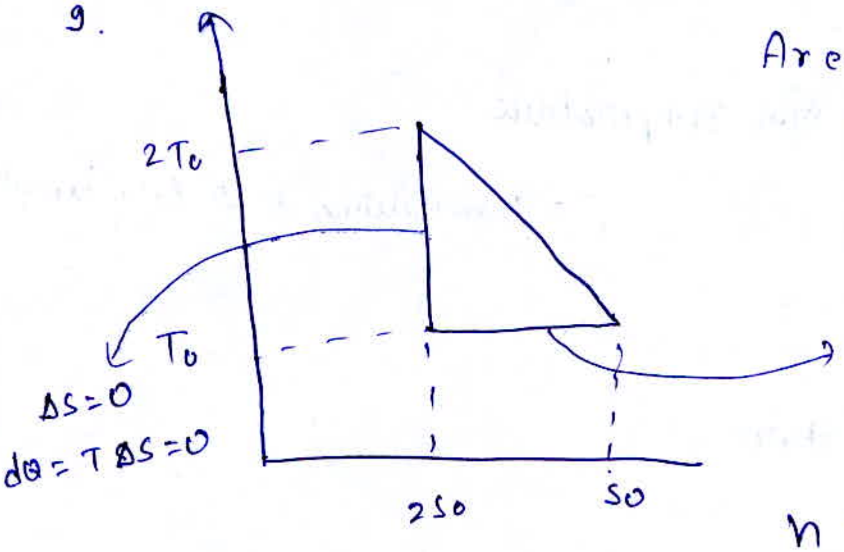
$$= 1 - \frac{27+273}{627+273}$$

$$= 1 - \frac{300}{900}$$

$$= \frac{2}{3}$$

7.

9.



Area of Cyclic Process = $Q_{in} - Q_{out}$

$= W$

$Q_{in} - Q_{out} = \frac{1}{2} T_0 S_0$

$dQ = T\Delta S$

$Q_{out} = T_0 S_0$

$$\eta = \frac{Q_{in} - Q_{out}}{Q_{in}}$$

$$= \frac{1/2\, T_0 S_0}{\frac{1}{2} T_0 S_0 + T_0 S_0} = \frac{1}{3}$$

10. —

11. $$\eta = 1 - \frac{T_2}{T_1}$$

~~$\frac{1}{2} = 1 - \frac{300}{T_1}$~~ $$\frac{2}{5} = 1 - \frac{300}{T_1}$$

$T_1 =$ $$\frac{300}{T_1} = \frac{3}{5}$$

$T_1 = 500$ K

$$\frac{60}{100} = 1 - \frac{300}{T_1'}$$

$$\frac{300}{T_1} = \frac{4}{10} = \frac{2}{5}$$

$T_1' =$ ~~600 K~~ 750 K

$T_1' - T_1 = 250$ K

12. $$\frac{1}{2} = 1 - \frac{273+50}{T_1}$$

~~D~~. $\frac{323}{T_1} = \frac{1}{2}$ $T_1 = 646$ K

$= 646 - 273$

$= 373$ °C

13. $\frac{1}{6} = 1 - \frac{T_2}{T_1}$

$\frac{T_2}{T_1} = \frac{5}{6}$

$\frac{1}{3} = 1 - \frac{T_2 - 62}{T_1}$

$\frac{T_2 - 62}{T_1} = \frac{2}{3}$

$\frac{T_2}{T_1} - \frac{62}{T_1} = \frac{2}{3}$

$\frac{5}{6} - \frac{2}{3} = \frac{62}{T_1}$

$\frac{5-4}{6} = \frac{62}{T_1}$

$T_1 = 62 \times \frac{6}{1}$ = ~~360 K~~ 372 K

= 372 − 273

= 99° C

14. $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{127+273}{227+273} = 1 - \frac{400}{500}$

$= \frac{1}{5}$

$\eta = \frac{1}{5} = \frac{W}{Q_{in}}$

$W = \frac{1}{5} \times 6$ = ~~kcal.~~

= 1.2 kcal

15. $$\eta = 1 - \frac{T_2}{T_1}$$

$$= 1 - \frac{27+273}{127+273}$$

$$= 1 - \frac{3}{4}$$

$$= \frac{1}{4}$$

$$\eta = \frac{W}{Q_{in}}$$

$$\frac{1}{4} = \frac{W}{40\,KJ}$$

$$W = 10\,KJ$$

16. $$\eta = \frac{1}{6} = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = \frac{5}{6}$$

$$\frac{1}{3} = 1 - \frac{T_2 - 62}{T_1}$$

$$\frac{+T_2 \mp 62}{T_1} = \frac{2}{3}$$

$$\cancel{\frac{62}{T_1} = \frac{2}{3} + \frac{T_2}{T_1} = \frac{2}{3} + \frac{5}{6}}$$

$$\cancel{= \frac{4+5}{6} = \frac{3}{2}}$$

$$\frac{T_2}{T_1} - \frac{62}{T_1} = \frac{2}{3}$$

$$\frac{62}{T_1} = \frac{5}{6} - \frac{2}{3}$$

$$\cancel{T_1 = \frac{62 \times 2}{3}}$$

$$\frac{62}{T_1} = \frac{5-4}{6} = \frac{1}{6}$$

$$\Rightarrow T_1 = 372\,K$$

17. (B)

18. (A)

19. Heated, Mechanic. Electric → Mechanical → Heat

20.

$$\cancel{\frac{W}{Q_{in}}} = 1 - \cancel{\frac{273}{303}} = \cancel{\frac{30}{303}}$$

$$Q_{in} = \cancel{\frac{303}{30} \times 1} =$$

$$\beta = \frac{T_2}{T_1 - T_2} = \frac{273}{303 - 273} = \frac{273}{30}$$

$$\beta = \frac{\text{Heat extracted } (Q_e)}{\text{work done}} = \frac{\cancel{273}^{91}}{\cancel{30}}$$

$$(Q_e) \text{ Heat extracted} = 9.1$$

$$Q_1 = Q_2 + W$$

$$= 9.1 + 1 = 10 \text{ J}$$

21.

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\frac{1}{5} = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = \frac{4}{5}$$

$$\frac{1}{3} = 1 - \frac{T_2 - 50}{T_1}$$

$$\frac{T_2 - 50}{T_1} = \frac{2}{3} \Rightarrow \frac{T_2}{T_1} - \frac{50}{T_1} = \frac{2}{3}$$

$$\frac{4}{5} - \frac{50}{T_1} = \frac{2}{3}$$

$$\frac{50}{T_1} = \frac{4}{5} - \frac{2}{3}$$

$$\frac{50}{T_1} = \frac{2}{15}$$

$$T_1 = 15 \times 25$$

$$T_1 = 375\ K$$

$$1 - \frac{T_2}{T_1} = \frac{1}{5}$$

$$T_2 = \frac{4}{\cancel{5}} \times \overset{75}{\cancel{375}}$$

$$T_2 = 300\ K$$

23. $$\eta = 1 - \frac{293}{313}$$

$$= \frac{20}{313} =$$

$$= \frac{20}{313} \times 100\ \%$$

$$= 6.4\ \%$$

24. $$\eta = 1 - \frac{T_2}{T_1}$$

For $\eta = 1$

$T_2 = 0$

Not possible

25.

$$\eta = 1 - \frac{T_2}{T_1}$$

$$= 1 - \frac{27+273}{677+273}$$

$$= 1 - \frac{300}{950} = \frac{650}{950} = \frac{13}{19}$$

$$\frac{W}{Q_{in}} = \frac{13}{19}$$

$$W = \frac{13}{19} \times 100 \quad \text{kcal}$$

$$= \frac{13}{19} \times 100 \times 4.2 \times 10^3 \text{ Joules}$$

$$= 0.28 \times 10^6 \text{ Joules}$$