CLASS TEST

Sl. : 01DLSK_ME_ABCDEFGH_040526

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THERMODYNAMICS

MECHANICAL ENGINEERING

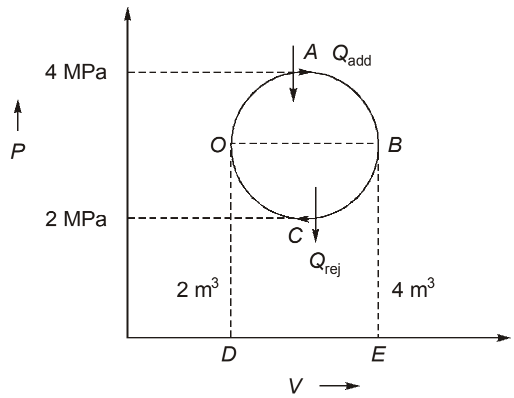
Date of Test : 04/05/2026

ANSWER KEY

1.	(d)	7.	(a)	13.	(c)	19.	(c)	25.	(c)
2.	(c)	8.	(a)	14.	(c)	20.	(b)	26.	(a)
3.	(b)	9.	(a)	15.	(b)	21.	(b)	27.	(c)
4.	(a)	10.	(a)	16.	(b)	22.	(b)	28.	(c)
5.	(b)	11.	(a)	17.	(d)	23.	(a)	29.	(b)
6.	(a)	12.	(b)	18.	(a)	24.	(c)	30.	(a)

DETAILED EXPLANATIONS

1. (d)



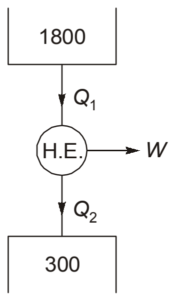
In cycle $Q_{net} = W_{net}$ = Area enclosed by cycle.

$$= \frac{\pi}{4}\times(4-2)\times(4000-2000) = 3141.59 \text{ kJ}$$

2. (c)

3. (b)
Hydrogen and Helium when throttled become heated as the maximum inversion temperature is below the normal ambient temperature.

4. (a)



$$Q_1 = 5 \text{ MW}$$
$$Q_2 = Q_1 - W = 3 \text{ MW}$$
$$\text{Rate of entropy generation} = \frac{-Q_1}{T_1} + \frac{Q_2}{T_2}$$
$$\Delta S_{gen} = \left(\frac{-5}{1800} + \frac{3}{300}\right)\times 10^6$$
$$\Delta S_{gen} = 7222.22 \text{ W/K}$$
$$\text{Work lost} = T_2 \Delta S_{gen} = 300 \times 7222.22 = 2.16 \text{ MW}$$

5. (b)
At $t = 0°\text{C}; P = 3$

$\Rightarrow$ $0 = a\log_e 3 + \frac{b}{2}$ ...(1)

at $t = 100°\text{C}; P = 8$

$\Rightarrow \quad 100 = a \log_e 8 + \frac{b}{2}$ ...(2)

By (1) and (2)

$$a = 101.95$$
$$b = -224$$

$\Rightarrow \quad t = 101.95 \log_e(P) - 112$

at $\quad P = 6.5;\ t = 78.83°C$

6. (a)

7. (a)

8. (a)

Considering compression as a quasi-static polytropic process,

We have, $\quad P_1V_1^n = P_2V_2^n$

Index of compression,

$$n = \frac{\ln(P_1/P_2)}{\ln(V_2/V_1)}$$

$$\therefore \quad n = \frac{\ln(1/6)}{\ln(0.03/0.12)}$$

$$\therefore \quad n = \frac{-1.7917}{-1.3863} = 1.292$$

9. (a)

10. (a)

11. (a)

$$P_1 = 400 \text{ kPa},$$
$$P_2 = 200 \text{ kPa},$$
$$P_{mix} = 250 \text{ kPa}$$
$$N_1 = 3 \text{ Kmol},$$
$$N_2 = 7 \text{ Kmol},$$
$$M_{N2} = 28 \text{ kg/Kmol}$$
$$M_{CO2} = 44 \text{ kg/Kmol}$$
$$N_{mix} = N_1 + N_2 = 10 \text{ Kmol}$$
$$y_1 = \frac{N_1}{N_{mix}} = 0.3$$
$$y_2 = 0.7$$
$$\therefore \quad P_{N2} = y_1 \times P_{mix} = 0.3 \times 250 \text{ kPa} = 75 \text{ kPa}$$

12. (b)

For the work to be maximum, the final temperature should be the geometric mean of the bodies temperatures.

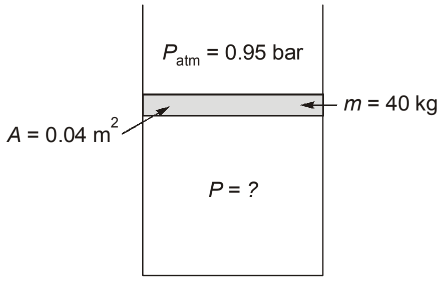
$$\therefore \quad T_f = \sqrt{T_1T_2}$$
$$= \sqrt{900 \times 400}\ ; \qquad T_f = 600 \text{ K}$$

13. (c)

Availability for a flow process,

$$= (h_1 - h_2) - T_0(S_1 - S_2)$$
$$= 300 - [300 \times (1.1 - 0.7)]$$
$$= 300 - 120$$
$$= 180 \text{ kJ/kg}$$

14. (c)



We have:

$$PA = P_{atm}A + W$$
$$P = P_{atm} + mg/A$$
$$P = 0.95 \text{ bar} + \frac{(40 \times 9.81)}{0.04 \times 10^5} \text{bar}$$
$$\Rightarrow \quad P = 1.0481 \text{ bar}$$

15. (b)

We know by 1st law of thermodynamics,

$$\Delta Q = \Delta U + \Delta W$$
$$(40 - 8) = \Delta U + \frac{-500}{1000}$$
$$\therefore \quad 32 = \Delta U - 0.5$$
$$\Delta U = 32.5$$
$$U_2 - U_1 = 32.5$$
$$U_2 - 10 = 32.5$$
$$\therefore \quad U_2 = 32.5 + 10$$
$$\therefore \quad U_2 = 42.5 \text{ kJ}$$

16. (b)

At triple point all the three phases exist in equilibrium.

∴ Triple point pressure of liquid and solid X are same.

$$\therefore \quad 12.14 - \frac{3000}{T} = 19.76 - \frac{3500}{T}$$
$$\therefore \quad \text{on solving, } T = 65.61 \text{ K}$$

17. (d)

$$\dot{Q}_H = \dot{W}_{net} + \dot{Q}_L$$
$$= 6000 + 3500$$
$$= 9500 \text{ kJ/min}$$

Also,

$$\dot{Q}_A + \dot{Q}_B = \dot{Q}_H$$
$$\dot{Q}_A + \dot{Q}_B = 9500 \text{ kJ/min} \quad \text{...(1)}$$

Also, $\dfrac{\dot{Q}_A}{T_A} + \dfrac{\dot{Q}_B}{T_B} = \dfrac{3500}{200}$

$\therefore$ $\dot{Q}_A + 2\dot{Q}_B = 14000$ ...(2)

Solving (1) and (2), $\dot{Q}_A = 5000$ kJ/min

$\dot{Q}_B = 4500$ kJ/min

18. (a)

$$Tds = dH - Vdp$$

Reversible adiabatic, $Tds = 0$

$$dH = Vdp$$

$$h_1 + q = h_2 + W_{cv}$$

$$W_{cv} = h_1 - h_2$$

$$W_{cv} = -Vdp$$

$$P_1 = 0.5 \text{ MPa},$$

$$V_1 = 0.2 \text{ m}^3$$

$$V_2 = 0.05 \text{ m}^3$$

$$PV^{1.3} = \text{Constant}$$

$$\Rightarrow \quad P_2 = P_1\left(\frac{V_1}{V_2}\right)^n$$

$$\Rightarrow \quad P_2 = 0.5 \times \left(\frac{0.20}{0.05}\right)^{1.3} = 3.031 \text{ MPa}$$

$$V = \left(\frac{C}{P}\right)^{1/1.3}$$

$$\int_{H_1}^{H_2} dH = \int_{P_1}^{P_2} Vdp$$

$$H_2 - H_1 = \frac{n[P_2V_2 - P_1V_1]}{n-1} = \frac{1.3[3031 \times 0.05 - 500 \times 0.2]}{1.3 - 1}$$

$$\Delta H = 223.3 \text{ kJ}$$

19. (c)

$$R_e = \frac{\Sigma mR}{\Sigma m}$$

$$\Rightarrow \quad R_e = 0.77 \times \frac{8.314}{32} + 0.23 \times \frac{8.314}{28}$$

$$\Rightarrow \quad R_e = 0.268 \text{ kJ/kgK}$$

$$[C_v]_e = \frac{R_e}{\gamma - 1} = \frac{0.268}{0.4} = 0.671 \text{ kJ/kg-K}$$

Constant volume process

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

$$\Rightarrow \quad T_2 = 2T_1$$

$$\Rightarrow \quad T_2 = 596 \text{ K}$$

$$\text{Heat supplied} = m(C_v)_e \Delta T$$

$$= 2 \times 0.671 \times 298 = 399.916 \text{ kJ}$$

$$\simeq 400 \text{ kJ}$$

20. (b)

$$\text{Mass} = 10 \text{ g} = 0.01 \text{ kg}$$

$$P = 10^5 \text{ Pa}$$

$$dQ = Q_{H_2O\,0°-100°C} + Q_{H_2O-Steam}$$

$$= 0.01 \times 4200 \times 100 + 2.5 \times 10^6 \times 0.01$$

$$= 29200 \text{ J}$$

$$dW = P\Delta V$$

$$\Delta V = \frac{0.01}{0.6} - \frac{0.01}{1000} = 0.016656 \text{ m}^3$$

$$dW = 0.016656 \times 10^5$$

$$= 1665.67 \text{ J}$$

$$dQ = dW + du$$

$$\Rightarrow \quad du = dQ - dW$$

$$= 29200 - 1665.67 = 27534.33 \text{ J} = 27.534 \text{ kJ}$$

21. (b)

$$W_{max} = (u_1 - u_2) - T_0(s_1 - s_2)$$

$$= c_v(T_1 - T_2) - T_0\left(c_p \ln\frac{T_1}{T_2} - R\ln\frac{P_1}{P_2}\right)$$

$$= 0.716(300 - 600) - 300\left[1.004\ln\frac{300}{600} - 0.287\ln\frac{1}{8}\right]$$

$$= -185.06 \text{ kJ/kg}$$

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

$$\Rightarrow \quad \frac{n-1}{n} = \frac{\ln\left(\frac{T_2}{T_1}\right)}{\ln\left(\frac{P_2}{P_1}\right)} = \frac{\ln 2}{\ln 8} = 0.333$$

$$\Rightarrow \quad n = 1.5$$

$$W_{actual} = \frac{mR(T_1 - T_2)}{n-1} = \frac{1 \times 0.287(300 - 600)}{1.5 - 1} = -172.2 \text{ kJ/kg}$$

$$\text{Irreversibility, } I = W_{max} - W_{actual}$$

$$= 185.06 - 172.2 = 12.86 \text{ kJ/kg}$$

22. (b)

The paddle wheel does work on the system (the gas) due to the 100 kg mass dropping 3 m. That work is negative

$$W_1 = -F \times d = -100 \times 9.81 \times 3 = -2943 \text{ J}$$

The work done by the system on this friction piston is positive,

$$W_2 = (PA)(h) = PV = (100 + 100) \times 0.002$$
$$= 0.4 \text{ kJ} = 400 \text{ J}$$

$$\therefore \quad W_{net} = -2943 + 400 = -2543 \text{ J}$$

23. (a)

Equation of the line *PQ*

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

$$P - 2P_0 = \frac{P_0 - 2P_0}{2V_0 - V_0}[V - V_0]$$

$$P - 2P_0 = -\frac{P_0}{V_0}[V - V_0]$$

$$P - 2P_0 = -\frac{P_0 V}{V_0} + P_0$$

$$\Rightarrow \quad P = -\frac{P_0}{V_0}V + 3P_0$$

$$\Rightarrow \quad PV = -\frac{P_0}{V_0}V^2 + 3P_0 V$$

$$\Rightarrow \quad n\bar{R}T = -\frac{P_0}{V_0}V^2 + 3P_0 V$$

$$\Rightarrow \quad T = \frac{1}{n\bar{R}}\left(-\frac{P_0}{V_0}V^2 + 3P_0 V\right)$$

For maximum temperature, $\frac{dT}{dV} = 0$

$$\Rightarrow \quad -\frac{2P_0 V}{V_0} + 3P_0 = 0$$

$$\Rightarrow \quad V = \frac{3V_0}{2}$$

$$\therefore \quad T_{max} = \frac{1}{n\bar{R}}\left(-\frac{P_0}{V_0} \times \frac{9V_0^2}{4} + 3P_0 \times \frac{3V_0}{2}\right) = \frac{9P_0 V_0}{4n\bar{R}}$$

24. (c)

Total electrical work which is converted to heat

$$= (VI)t = 22 \times 1.6 \times 90 = 3168 \text{ J} = Q$$

$$\text{Work done by air} = \int PdV = 1.1 \times 10^5 \times 0.02$$
$$= 2200 \text{ J} = W$$

From I[st] law, $\delta Q = \Delta U + \delta W$

$$3168 = \Delta U + 2200$$
$$\Delta U = 968 \text{ J}$$

$$mC_V\Delta T = 968$$
$$0.1 \times 717 \times \Delta T = 968$$
$$\Delta T = 13.5°C$$

25. (c)

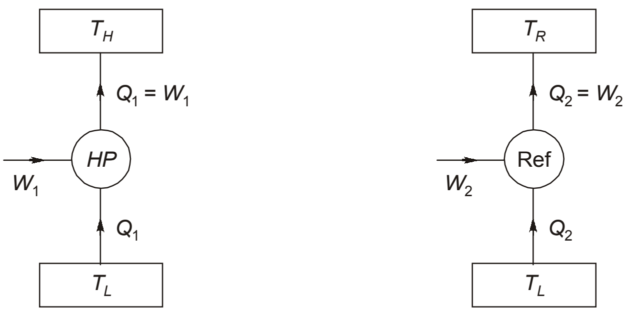
$$(\Delta s)_{gen.} = (\Delta s)_{ice} + (\Delta s)_{atm.}$$
$$(\Delta s)_{ice} = 1 \times 2.093 \times \ln\frac{273}{268} + \frac{333.3}{273} + 1 \times 4.18 \times \ln\frac{293}{273}$$
$$= 1.555$$
$$Q_{ice} = 1 \times 2.093 \times 5 + 333.3 + 1 \times 4.18 \times 20 = 427.365$$
$$(\Delta s)_{surr.} = \frac{-Q_{ice}}{293} = -1.459$$
$$(\Delta s)_{gen.} = 1.555 - 1.459 = 0.096 \text{ kJ/kg}$$

26. (a)

Unsteady Flow

$$\frac{dm}{dt} = \dot{m}_i - \dot{m}_e$$
$$dm = m_i - m_e$$
$$m_2 - m_1 = m_i - m_e$$
$$m_2 = m_i$$
$$\frac{dE}{dt} = \frac{d}{dt}(m_i h_i) = \frac{dU}{dt}$$
$$\Rightarrow \quad m_2 u_2 - m_1 u_1 = m_i h_i$$
$$\Rightarrow \quad m_2 u_2 = m_i h_i$$
$$\Rightarrow \quad C_v T_2 = C_p T_i$$
$$\Rightarrow \quad T_2 = \gamma T_i$$
$$\Rightarrow \quad T_2 = 1.66 \times 433 = 718.78 \text{ K}$$
$$T_2 = 445.78°C$$

27. (c)



For heat pump

$$\frac{T_H}{T_H - T_L} = 5$$
$$\Rightarrow \quad T_H = 5(T_H - T_L)$$
$$\Rightarrow \quad 4T_H = 5T_L$$

$$\Rightarrow \qquad T_H = \frac{5}{4}T_L$$

For refrigerator

$$\frac{T_L}{T_R - T_L} = 5$$

$$\Rightarrow \qquad T_L = 5(T_R - T_L)$$

$$\Rightarrow \qquad 5T_R = 6T_L$$

$$\Rightarrow \qquad T_R = \frac{\left(\frac{5}{4}\right)}{\left(\frac{6}{5}\right)} = \frac{25}{24}$$

28. (c)

29. (b)

30. (a)

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