



MADE EASY

Leading Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Pune

Web: www.madeeasy.in | E-mail: info@madeeasy.in | Ph: 011-45124612

POWER PLANT

MECHANICAL ENGINEERING

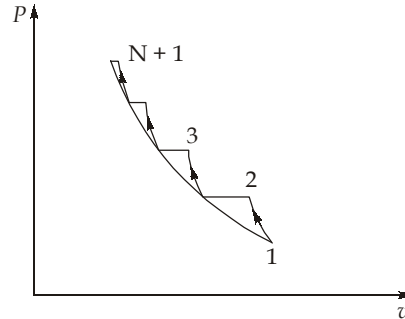
Date of Test : 29/10/2026

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (a)



Let N be the number of stages.

$$P_1 = 1 \text{ bar}, T_1 = 27 + 273 = 300 \text{ K}$$

$$P_{N+1} = 150 \text{ bar}$$

$$T_2 = 160^\circ\text{C} = 160 + 273 = 433 \text{ K}$$

For polytropic process, 1 - 2 ($n = 1.25$)

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1} \right)^{(1.25-1)/1.25}$$

$$P_2 = 6.2637 \text{ bar}$$

Now,

$$\frac{P_{N+1}}{P_1} = \frac{P_{N+1}}{P_N} \times \frac{P_N}{P_{N-1}} \dots \dots \dots \frac{P_3}{P_2} \times \frac{P_2}{P_1}$$

$$\frac{P_{N+1}}{P_1} = \left(\frac{P_2}{P_1} \right)^N$$

$$\Rightarrow \frac{150}{1} = \left(\frac{6.2637}{1} \right)^N$$

$$N = 2.731$$

$$N \simeq 3$$

2. (c)

$$T_{\max} = 1200^\circ\text{C} = 1200 + 273 = 1473 \text{ K}$$

$$T_{\min} = 80^\circ\text{C} = 80 + 273 = 353 \text{ K}$$

$$\gamma = 1.4$$

For maximum net work output, the pressure ratio is given as

$$\begin{aligned} (r_p)_{\text{optimum}} &= \left(\frac{T_{\max}}{T_{\min}} \right)^{\frac{\gamma}{2(\gamma-1)}} = \left(\frac{1473}{353} \right)^{\frac{1.4}{2(1.4-1)}} \\ &= 12.18285 \simeq 12.18 \end{aligned}$$

3. (a)

For maximum blade efficiency of Parson's turbine,
Speed ratio, $\rho = \cos \alpha$

4. (b)

Due to regeneration, mean temperature of heat addition increases resulting in increase in cycle efficiency and decrease in heat rate.

There is no change in mean temperature of heat rejection because of regeneration.

For same boiler output, net work output of cycle decreases.

5. (c)

- The stagnation temperature remains constant in an adiabatic flow because there is no heat transfer.
- The stagnation pressure decreases across a normal shock wave due to irreversible losses.
- The Mach number downstream of a normal shock is less than 1.
- The specific entropy increases across a normal shock wave due to the irreversibility of the shock wave, indicating an increase in disorder.

6. (c)

$$V_{w2} = u_2$$

$$\text{Degree of reaction} = 1 - \frac{V_{w2}}{2u_2}$$

$$= 1 - \frac{1}{2} = 0.5 = 50\%$$

7. (c)

- During reheating in steam turbine entropy increases.
- Sum of available energies for each stage is greater than available energies for whole turbine.

$$\text{Reheat factor} = \frac{\text{Sum of available energies for each stage}}{\text{Available energy for whole turbine}}$$

8. (b)

Approach of a cooling tower = $T_{\text{exit}} - T_{WBT}$

9. (a)

Nozzle angle, $\alpha = 19^\circ$

Blade inlet angle, $\theta = 28^\circ$

$V_{r1} = 300 \text{ m/s}$

From inlet velocity triangle,

$$V_{f1} = V_1 \sin \alpha = V_{r1} \sin \theta$$

$$V_1 \sin 19^\circ = V_{r1} \sin 28^\circ$$

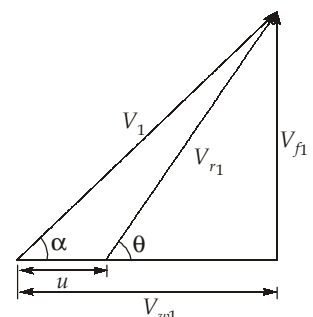
$$V_1 = \frac{300 \times \sin 28^\circ}{\sin 19^\circ}$$

$$V_1 = 432.602 \text{ m/s}$$

For maximum efficiency,

$$u = \frac{V_1 \cos \alpha}{2} = \frac{432.602 \times \cos 19^\circ}{2}$$

$$u = 204.517 \text{ m/s}$$



Inlet velocity triangle

Work done per kg of steam,

$$\begin{aligned}
 w &= (V_{w1} + V_{w2}) \times u \\
 &= [(V_{r1} \cos \theta + u) + (V_{r2} \cos \phi - u)] \times u \\
 &= (V_{r1} \cos \theta + V_{r2} \cos \phi) u \\
 &= 300(\cos 28^\circ + \cos 22^\circ) \times 204.517 \quad [\because V_{r1} = V_{r2}] \\
 &= 111060.796 \text{ J/kg} = 111.06 \text{ kJ/kg}
 \end{aligned}$$

10. (a)

Pressure ratio, $r_p = 6$

$$T_2 = 400 + 273 = 673 \text{ K}$$

$$T_3 = 1200 + 273 = 1473 \text{ K}$$

Process 1-2 (Isentropic)

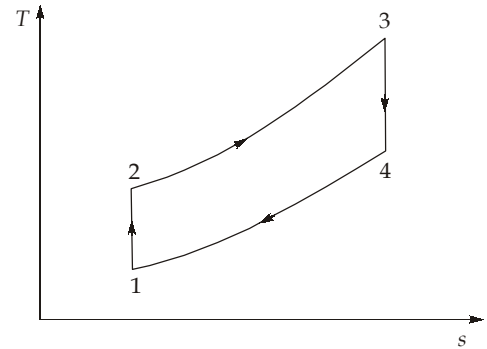
$$\frac{T_2}{T_1} = r_p^{\gamma-1/\gamma}$$

$$\frac{673}{T_1} = (6)^{(1.4-1)/1.4}$$

$$T_1 = 403.354 \text{ K}$$

As we know,

$$\begin{aligned}
 \eta_{\text{reg}} &= 1 - \frac{T_1}{T_3} r_p^{\gamma-1/\gamma} = 1 - \frac{403.354}{1473} \times 6^{(1.4-1)/1.4} \\
 &= 0.5431 = 54.31\%
 \end{aligned}$$



11. (d)

$$W_t = 120 \text{ kJ}, W_c = 60 \text{ kJ}, Q = 200 \text{ kJ}$$

$$\eta_1 = \frac{W_t - W_c}{Q_1} = 30\%$$

As regenerator would recover 40% of energy from exhaust. The overall thermal efficiency would be

$$\eta_2 = \frac{W_t - W_c}{Q_1 - 0.4(Q_1 - W_t)} = \frac{120 - 60}{200 - 0.4(200 - 120)} = \frac{60}{168} = 35.7\%$$

% increase in overall thermal efficiency

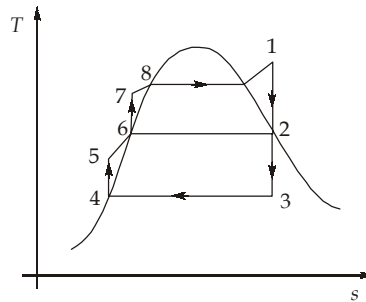
$$= \frac{n_2 - n_1}{n_1} \times 100 = \frac{35.7 - 30}{30} \times 100 = 19\%$$

12. (a)

Surface condensers are bulky and expensive.

13. (b)

14. (a)



$$h_7 - h_6 = 3 \text{ kJ/kg}$$

$$h_5 - h_4 = 1 \text{ kJ/kg}$$

$$h_1 = 3514 \text{ kJ/kg}$$

$$h_4 = 613 \text{ kJ/kg}$$

$$\begin{aligned} \text{Heat transferred in boiler} &= (h_1 - h_4) - (h_7 - h_6) - (h_5 - h_4) \\ &= (3514 - 613) - 3 - 1 = 2897 \text{ kJ/kg} \end{aligned}$$

15. (b)

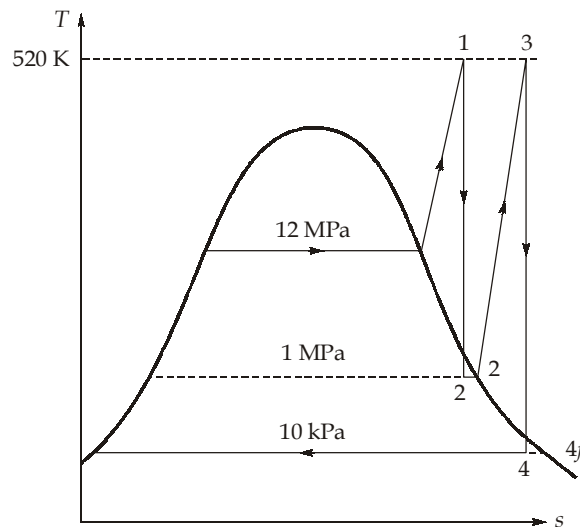
$$h_1 = 3401.8 \text{ kJ/kg}; s_1 = 6.5555 \text{ kJ/kgK} = s_2; h_{2g} = 6.5865$$

$$s_2 = s_{2f} + x_2(s_{2g} - s_{2f})$$

$$6.5555 = 2.1387 + x_2(6.5865 - 2.1387)$$

$\Rightarrow$

$$x_2 = 0.993$$



$$s_3 = 7.8171 \text{ kJ/kgK} = s_4$$

$$s_{4g} = 8.151 \text{ kJ/kgK}$$

Now,

$$s_4 = s_{4f} + x_4(s_{4g} - s_{4f})$$

$$7.8171 = 0.6493 + x_4(8.151 - 0.6493)$$

$\Rightarrow$

$$x_4 = 0.955$$

16. (d)

The Benson boiler feed pump feeds water to economizer from where it goes to radiant heating section here, most of the heat is transmitted and water gets heated almost to the critical temperature in the evaporative section the evaporation is completed and superheating super heating is done by convective super heater and radiation superheater after super heater the final temperature is obtained.

17. (d)

$$T_3 = 1250^\circ\text{C} = 1523 \text{ K}$$

$$T_2 = 500^\circ\text{C} = 773 \text{ K}$$

$$r_p = 7$$

$$C_p = 1 \text{ kJ/kgK}, \gamma = 1.4$$

Process 1 - 2 is isentropic compression ;

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

$$\Rightarrow T_1 = \frac{T_2}{\left(r_p\right)^{\frac{\gamma-1}{\gamma}}} = \frac{773}{\left(7\right)^{\left(\frac{1.4-1}{1.4}\right)}} = 443.326 \text{ K}$$

The cycle efficiency for ideal regenerative Brayton cycle is given as

$$\begin{aligned} \eta &= 1 - \frac{T_1}{T_3} \cdot \left(r_p\right)^{\frac{\gamma-1}{\gamma}} = 1 - \frac{443.326}{1523} \times (7)^{\left(\frac{1.4-1}{1.4}\right)} \\ &= 0.49245 = 49.245\% \simeq 49.25\% \end{aligned}$$

18. (b)

$$\text{Chimney efficiency, } \eta = \frac{gH_1}{C_{pg}(T_g - T_{ga})} = \frac{9.81 \times 720}{900 \times (380 - 355)} = 31.39\%$$

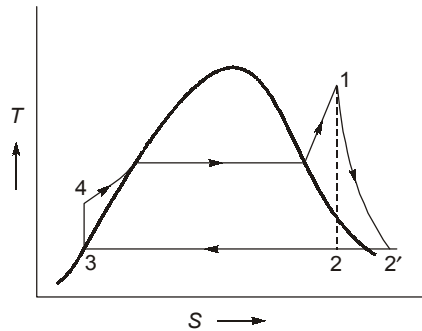
19. (a)

$$\text{Propulsive power of rocket} = \frac{\dot{m}_a (V_j^2 - V_a^2)}{2} = \frac{2.2 \times (600^2 - 550^2)}{2} = 63.25 \text{ kW}$$

20. (c)

$$\begin{aligned} \eta_{\text{Combined}} &= \eta_1 + \eta_2 - \eta_1 \eta_2 = 0.75 + 0.40 - 0.75 \times 0.40 \\ \Rightarrow \% \eta_{\text{Combined}} &= 85\% \end{aligned}$$

21. (d)



$$h_1 = 2295 \text{ kJ/kg}$$

$$s_1 = 6.5422 \text{ kJ/kgK}$$

$$s_{3f} = 0.4763 \text{ kJ/kgK}$$

$$s_{2'} = 8.396 \text{ kJ/kgK}$$

$$s_2 = s_{3f} + x(s_{2'} - s_{3f})$$

$$s_2 = 0.4763 + x(8.396 - 0.4763)$$

$$s_1 = 6.5422$$

$\therefore$

$$x = \frac{6.5422 - 0.4763}{8.396 - 0.4763} = 0.7659$$

22. (b)

The cyclone separators collection efficiency increases with increasing:

1. Particle size
2. Particle density
3. Inlet gas velocity
4. Cyclone body length
5. Number of gas revolutions
6. Smoothness of cyclone walls

23. (b)

As $\eta_{th} = 0.333 \simeq \frac{1}{3} = \frac{W}{Q_{in}}$ or $Q_{in} = 3 \times 500$

$\Rightarrow Q_{in} = 1500 \text{ MW}$, now heat rejected $Q_r = Q_{in} - W = 1000 \text{ MW}$

As heat will be carried away by cooling water, so

$$M_W \times C_{PW} \times (\Delta T)_W = 1000 \times 10^3 \text{ kW}$$

$$M_W \times 4.2 \times 5 = 1000 \times 10^3 \text{ kW}$$

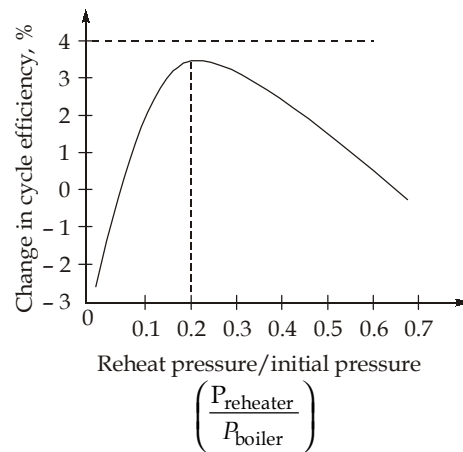
$\Rightarrow m_w = 47.62 \times 10^3 \text{ kg/s}$

or $M_W = 47.62 \text{ tons/s}$

or $M_W = 47.62 \times 3600 \text{ tons/hr}$

$$M_W = 1.71 \times 10^5 \text{ tons/hr}$$

24. (c)



25. (c)

Given : $\gamma = 1.3$; $R = 0.469 \text{ kJ/kgK}$; $P_1 = 2.55 \text{ bar}$; $M_1 = 1.5$; $T_1 = 26.5 + 273 = 299.5 \text{ K}$

The stagnation temperature is given as

$$\begin{aligned}
 T_{01} &= T_1 \left[1 + \frac{\gamma - 1}{2} M_1^2 \right] \\
 &= 299.5 \times \left[1 + \frac{1.3 - 1}{2} \times (1.5)^2 \right] = 299.5 \times 1.3375 \\
 &= 400.58125 \text{ K} \simeq 400.6 \text{ K}
 \end{aligned}$$

■■■■