CLASS TEST

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POWER PLANT

MECHANICAL ENGINEERING

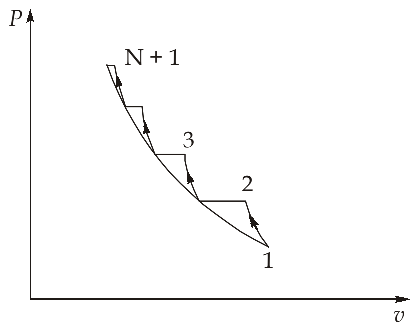
Date of Test : 01/09/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)



Let N be the number of stages.

$$P_1 = 1 \text{ bar}, T_1 = 27 + 273 = 300 \text{ K}$$
$$P_{N+1} = 150 \text{ bar}$$
$$T_2 = 160°\text{C} = 160 + 273 = 433 \text{ K}$$

For polytropic process, 1 – 2(n = 1.25)

$$\frac{T_2}{T_1} = \left(\frac{P_2}{1}\right)^{(1.25-1)/1.25}$$
$$P_2 = 6.2637 \text{ bar}$$

Now,
$$\frac{P_{N+1}}{P_1} = \frac{P_{N+1}}{P_N} \times \frac{P_N}{P_{N-1}} \ldots\ldots\ldots\ldots \frac{P_3}{P_2} \times \frac{P_2}{P_1}$$
$$\frac{P_{N+1}}{P_1} = \left(\frac{P_2}{P_1}\right)^N$$
$$\Rightarrow \quad \frac{150}{1} = \left(\frac{6.2637}{1}\right)^N$$
$$N = 2.731$$
$$N \simeq 3$$

2. (b)

Reheating results in increase in net work output, decrease in thermal efficiency (thermal efficiency is directly proportional to mean temperature of heat addition) and improvement in quality of wet steam at turbine exit. But reheating is mainly incorporated in power plant to limit the moisture content in the working fluid at turbine exit. Due to increase in specific output, mass flow rate required is less for the same power output, which results in reduction in plant size.

3. (a)

For maximum blade efficiency of Parson's turbine,

$$\text{Speed ratio, } \rho = \cos\alpha$$

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)

6. (c)

$$V_{w_2} = u_2$$

$$\text{Degree of reaction} = 1 - \frac{V_{w_2}}{2u_2}$$

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

7. (c)

Turbojets have been replaced in slower aircraft due to poor efficiency and lower specific fuel consumption. At medium speed, turboprop has been replaced by turbofans.

8. (c)

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

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

9. (d)

Various boiler mounting are as under:

1. Pressure gauge
2. Water level indicator
3. Fusible plug
4. Safety valve
5. Steam stop valve
6. Feed check valve
7. Blow off cock.

10. (b)

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

11. (a)

$$\text{Nozzle angle, } \alpha = 19°$$

$$\text{Blade inlet angle, } \theta = 28°$$

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

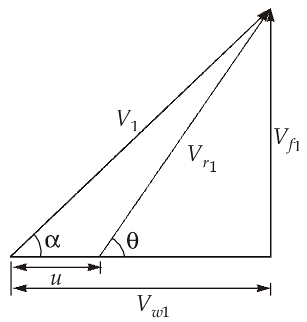
From inlet velocity triangle,

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

$$V_1 \sin 19° = V_{r1} \sin 28°$$

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

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



Inlet velocity triangle

For maximum efficiency,

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

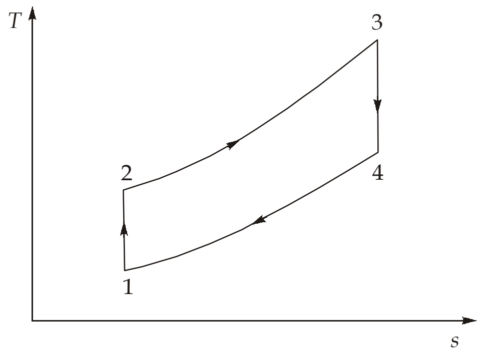
$$u = 204.517 \text{ m/s}$$

Work done per kg of steam,

$$w = (V_{w1} + V_{w2}) \times u$$
$$= [(V_{r1}\cos\theta + u) + (V_{r2}\cos\phi - u)] \times u$$
$$= (V_{r1}\cos\theta + V_{r2}\cos\phi)u$$
$$= 300(\cos 28° + \cos 22°) \times 204.517 \qquad [\because V_{r1} = V_{r2}]$$
$$= 111060.796 \text{ J/kg} = 111.06 \text{ kJ/kg}$$

12. (a)

$$\text{Pressure ratio, } r_p = 6$$
$$T_2 = 400 + 273 = 673 \text{ K}$$
$$T_3 = 1200 + 273 = 1473 \text{ K}$$



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,

$$\eta_{reg} = 1 - \frac{T_1}{T_3} r_p^{\gamma-1/\gamma} = 1 - \frac{403.354}{1473} \times 6^{(1.4-1/1.4)}$$

$$= 0.5431 = 54.31\%$$

14. (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

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

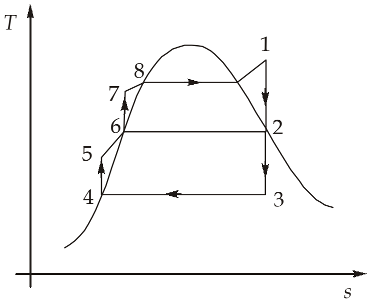
% increase in overall thermal efficiency

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

15. (a)

Surface condensers are bulky and expensive.

17. (a)



$$h_7 - h_6 = 3 \text{ kJ/kg}$$
$$h_5 - h_4 = 1 \text{ kJ/kg}$$
$$h_1 = 3514 \text{ kJ/kg}$$
$$h_4 = 613 \text{ kJ/kg}$$

Heat transferred in boiler $= (h_1 - h_4) - (h_7 - h_6) - (h_5 - h_4)$

$= (3514 - 613) - 3 - 1 = 2897$ kJ/kg

18. (c)

For maximum discharge of hot gases through the chimney height of hot gas column producing draught is equal to the height of the chimney.

19. (b)

$$h_3 = Xh_1 + (1 - X)h_2$$
$$720 = X \times 2800 + (1 - X)\, 200$$
$$X = 0.2 = 20\%$$

20. (b)

$$T_1 = 5°\text{C} = 5 + 273 = 278 \text{ k}$$
$$T_2 = 839°\text{C} = 839 + 273 = 1112 \text{ k}$$

For maximum work

$$n_p = \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}} = \left(\frac{1112}{278}\right)^{\frac{1.4}{2(1.4-1)}} = (4)^{1.75} = 11.31$$

21. (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.

23. (b)

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

24. (a)

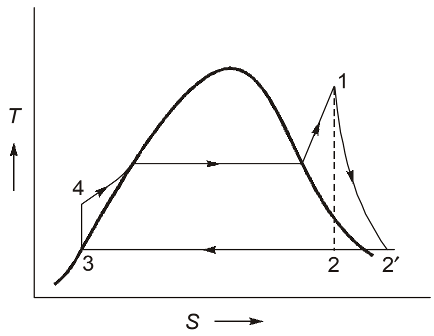
$$\text{Propulsive power of rocket} = \frac{\dot{m}_a\left(V_j^2 - V_a^2\right)}{2} = \frac{2.2 \times \left(600^2 - 550^2\right)}{2} = 63.25 \text{ kW}$$

25. **(c)**

$$\eta_{Combined} = \eta_1 + \eta_2 - \eta_1\eta_2 = 0.75 + 0.40 - 0.75 \times 0.40$$

$$\Rightarrow \quad \%\eta_{Combined} = 85\%$$

26. **(d)**



$$h_1 = 2295 \text{ kJ/kg}$$
$$s_1 = 6.5422 \text{ kJ/kgK}$$
$$s_{3f} = 0.4763 \text{ kJ/kgK}$$
$$s_{2'} = 8.396 \text{ kJ/kgK}$$
$$s_2 = s_{3f} + x\left(s_{2'} - s_{3f}\right)$$
$$s_2 = 0.4763 + x(8.396 - 0.4763)$$
$$s_1 = 6.5422$$

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

27. **(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

28. **(b)**

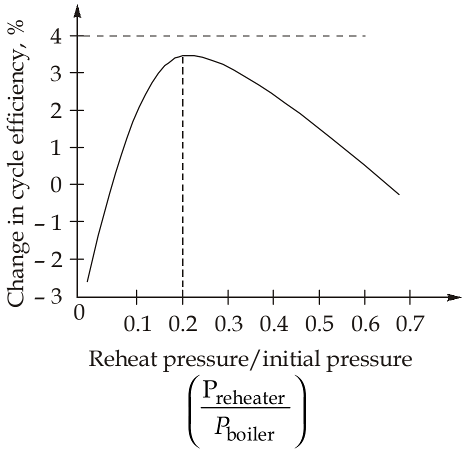
As $\quad \eta_{th} = 0.333 \simeq \frac{1}{3} = \frac{W}{Q_{in}}$ or $Q_{in} = 3 \times 500$

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

As heat will be carried away by cooling water, so

$$M_W \times C_{PW} \times (\Delta T)_W = 1000 \times 10^3 \text{ kW}$$
$$M_W \times 4.2 \times 5 = 1000 \times 10^3 \text{ kW}$$
$$\Rightarrow \quad m_w = 47.62 \times 10^3 \text{ kg/s}$$
$$\text{or} \quad M_W = 47.62 \text{ tons/s}$$
$$\text{or} \quad M_W = 47.62 \times 3600 \text{ tons/hr}$$
$$M_W = 1.71 \times 10^5 \text{ tons/hr}$$

29. (c)



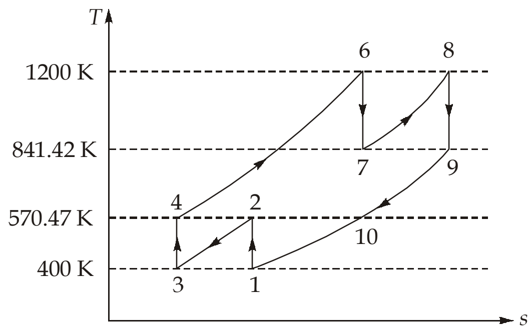
30. (a)

For perfect intercooler, $r_p = \dfrac{P_2}{P_1} = \dfrac{P_4}{P_3} = \sqrt{12} = 3.464,$

and $\dfrac{P_6}{P_7} = \dfrac{P_8}{P_9} = \sqrt{12} = 3.464,$

$\gamma(\text{air}) = 1.4$

$C_p(\text{air}) = 1.005$ kJ/kg· K



For ideal conditions, work output of each turbine and work input of each compressor would be same.

Now, $$T_4 = T_2 = T_1\left(r_p\right)^{\frac{\gamma-1}{\gamma}} = 400(3.464)^{\frac{1.4-1}{1.4}} = 570.47 \text{ K}$$

and $$T_9 = T_7 = \frac{T_8}{\left(r_p\right)^{\frac{\gamma-1}{\gamma}}} = \frac{1200}{(3.464)^{\frac{1.4-1}{1.4}}} = 841.42 \text{ K}$$

Now, total compressor work $= 2\left(h_2 - h_1\right) = 2C_p\left(T_2 - T_1\right) = 2 \times 1.005 \times (570.47 - 400)$

$= 342.65$ kJ/kg

and total work of turbine $= 2(h_6 - h_7) = 2C_p(T_6 - T_7) = 2 \times 1.005\ (1200 - 841.42)$

$= 720.74$ kJ/kg

So, back work ratio $= \dfrac{W_C}{W_T} = \dfrac{342.65}{720.74} = 0.475$

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