Problem A power system was designed to operate with two turbines and a regenerator as shown in Figure 1. The system generates a net power of

$$\Phi = \sum W_{\text{Turbines}} - \sum W_{\text{Pumps}}$$

and is coupled to a reversed-Rankine cycle to provide heating to a controlled environment. The heat extracted from the condenser (5-6) is fully transferred to the refrigerant fluid (13-10), i.e.,

$$Q_{\text{Condenser}} = \dot{m}_w^{5-6} \left(H_5 - H_6\right) = \dot{m}_R \left(H_{10} - H_{13}\right)$$

where $\dot{m}_w^{5-6}$ and $\dot{m}_R$ $(= 2\ kg/s)$ are the mass flow rates of water/steam leaving the Turbine LP and the refrigerant fluid R134a. To solve this problem, you should assume that the saturated liquid streams are incompressible, and therefore $dH = VdP$ (where H, V and P are enthalpy, volume and pressure, respectively). The efficiencies associated with the HP and LP turbines and pumps 1 (P1) and 2 (P2) are 98.5, 99, 65 and 73$\%$, respectively. Assume that the mass flow rate of water/steam leaving boiler (stream 1) is 1 kg/s

1. Calculate (A-W) and (i-ix) from the Table 1 **[66 Marks]**;
2. Calculate the heat suplied by the boiler **[17 Marks]**;
3. Calculate the thermal efficiency in the power cycle **[17 Marks]**.

Flow	**Pressure (bar)**	**Temperature (°C)**	**Enthalpy (kJ/kg)**	**Entropy (kJ/kg.K)**	**State**	**Quality of steam**
1	210.0	660	(A)	(B)	(C)	–
2	7.4	–	(D)	(E)	wet vapour	(F)
3	7.4	400	(G)	(H)	(I)	–
4	7.4	600	(J)	(K)	(L)	–
5	0.08	–	(M)	(N)	(O)	(P)
6	0.08	–	(Q)	(R)	(S)	–
7	7.4	–	(T)	–	–	–
8	–	–	(U)	(V)	–	–
9	(W)	–	(Y)	–	–	–
10	(i)	–	(ii)	–	(iii)	–
11	–	–	–	–	–	–
12	6.3	5.6	(iv)	(v)	(vi)	–
13	3.2	–	(vii)	(viii)	–	(ix)

Table 1: Information on the steam-power and refrigeration cycles.

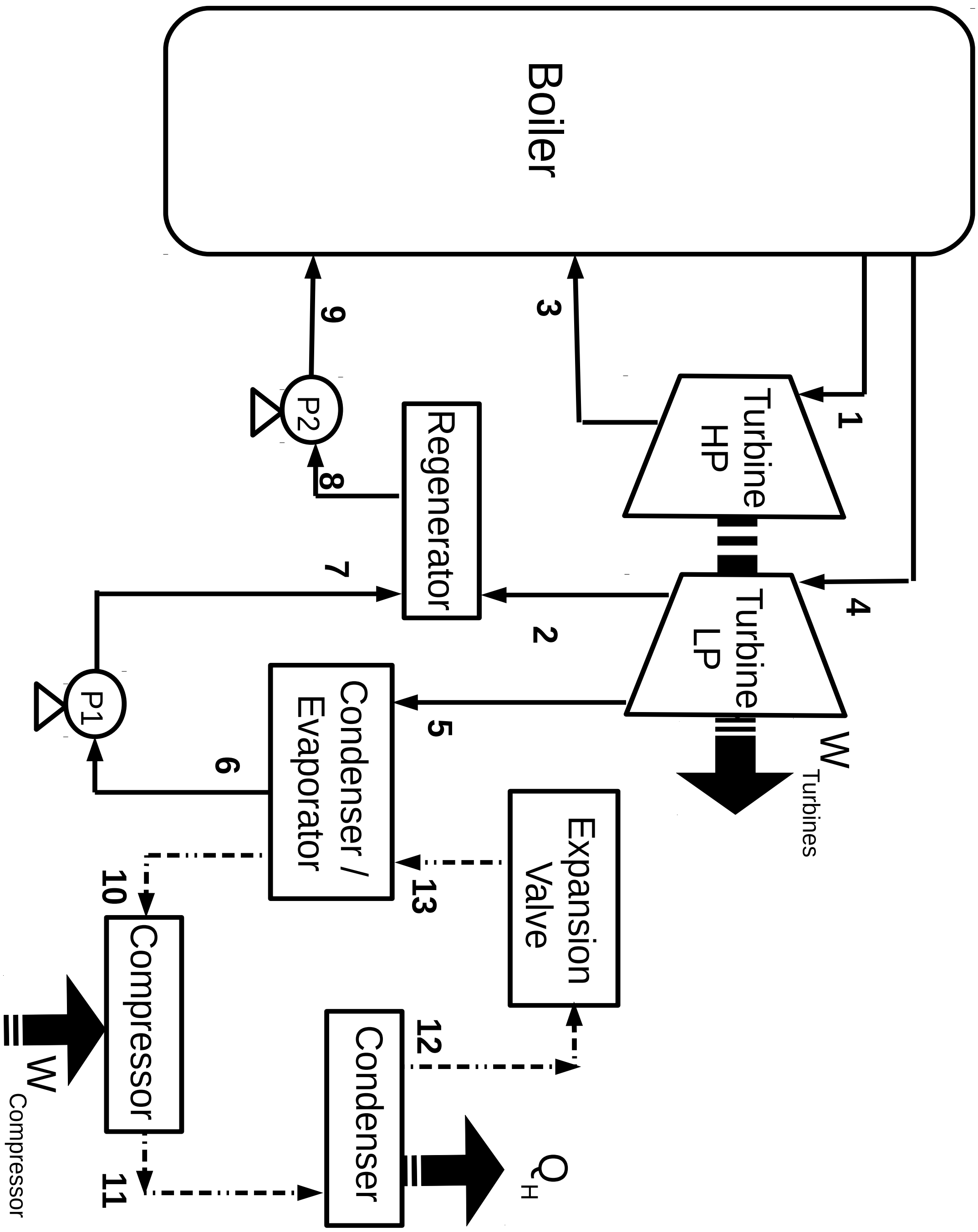

Figure 1: Regenerative Reheat Rankine (full line) and Reverse Rankine (dotline) cycles.