1. A Carnot heat engine receives 400 kJ of heat per cycle from a high-temperature source at 600°C and rejects heat to a low-temperature sink at 25°C. Determine (*a*) the thermal efficiency of this Carnot engine (10%) and (*b*) the amount of heat rejected to the sink per cycle. (10%)

2. The compressed-air requirements of a plant located at 1500-m elevation is being met by a 100-hp compressor that takes in air at the local atmospheric pressure of 90 kPa and the average temperature of 15°C and compresses it to 1000 kPa gauge. The plant is currently paying NT$400,000 a year in electricity costs to run the compressor. An investigation of the compressed air system and the equipment using the compressed air reveals that compressing the air to 800 kPa is sufficient for this plant. Determine how much money will be saved as a result of reducing the pressure of the compressed air. (10%)

3. Liquid methane is commonly used in various cryogenic applications. The critical temperature of methane is 191 K (or 82°C), and thus methane must be maintained below 191 K to keep it in liquid phase. The properties of liquid methane at various temperatures and pressures are given in Table 1. Determine the entropy change of liquid methane as it undergoes a process from 110 K and 1 MPa to 120 K and 5 MPa *(a)* using tabulated properties and (10%) (*b*) approximating liquid methane as an incompressible substance. What is the error involved in the latter case? (10%)

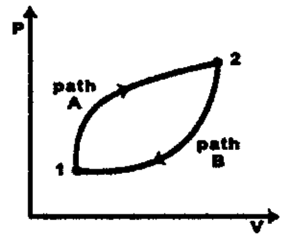
Table 1

Properties of liquid methane

| Temp., $T$, K | Pressure, $P$, MPa | Density, $\rho$, kg/m³ | Enthalpy, $h$, kJ/kg | Entropy, $s$, kJ/kg · K | Specific heat, $c_p$, kJ/kg · K |
|---|---|---|---|---|---|
| 110 | 0.5 | 425.3 | 208.3 | 4.878 | 3.476 |
| | 1.0 | 425.8 | 209.0 | 4.875 | 3.471 |
| | 2.0 | 426.6 | 210.5 | 4.867 | 3.460 |
| | 5.0 | 429.1 | 215.0 | 4.844 | 3.432 |
| 120 | 0.5 | 410.4 | 243.4 | 5.185 | 3.551 |
| | 1.0 | 411.0 | 244.1 | 5.180 | 3.543 |
| | 2.0 | 412.0 | 245.4 | 5.171 | 3.528 |
| | 5.0 | 415.2 | 249.6 | 5.145 | 3.486 |

4. A gas in a piston and cylinder device undergoes three quasi-equilibrium processes to complete a thermodynamic cycle. The following information is known about the three steps that make up the cycle.
Process 1-2: constant volume, V = 37 L, $\Delta U_{12} = 31.6$ kJ
Process 2-3: expansion with PV = constant and $\Delta U_{23} = 0$
Process 3-1: constant pressure, P = 155 kPa, $W_{31} = -15.1$ kJ
Assume changes in kinetic and potential energies are negligible.
*(a)* Calculate the total boundary work for the cycle in kJ (10%)
*(b)* Calculate $Q_{23}$ in kJ (10%)
*(c)* Calculate $Q_{31}$ in kJ (10%)
*(d)* Determine whether this cycle is a power cycle or a refrigeration/heat-pump cycle and calculate the coefficient of performance or thermal efficiency (10%)

5. Consider the cycle made of path A followed by path B shown below.




The following two integrals have been evaluated.

$\int_1^2 \left(\frac{\delta Q}{T}\right)_A = -24.7$ kJ/K　and　$\int_2^1 \left(\frac{\delta Q}{T}\right)_B = 41.3$ kJ/K

Is this cycle reversible, irreversible or impossible? (10%)

試題隨卷繳回