ME 354 THERMODYNAMICS LAB
THE REFRIGERATION CYCLE

INTRODUCTION:

The attached figure shows schematically the basic refrigeration unit located in the Heat Transfer Lab, E3-2108. The working substance is R11, trichlorofloromethane.
Carefully inspect the unit schematic and the cycle diagram. Identify the four key components of the basic refrigerator/heat pump: compressor, evaporator, condenser, and the expansion valve. Note that the unit is equipped with 2 pressure gauges, 6 thermometers, and 2 flow meters. Note that the pressure dials show the gauge pressure (not the absolute pressure), and that the flow meter readings are taken using the top of the float.
There is a voltmeter and an ammeter for determining the power input to the electric motor driving the compressor. Note that this crude *diaphragm-type* compressor has only a 55% efficiency, and the heat loss from the compressor to the surrounding air is estimated to be 18 W under typical operating conditions.

OPERATION:

Turn on the water supplies (arbitrary amounts) to the evaporator and condenser, then switch on the compressor and allow the cycle to stabilize. **DO NOT RUN THE UNIT WITH ZERO WATER FLOW**. Carefully observe the following processes in the cycle:

- **Process 1 - 2:** The compressor creates a low pressure in the evaporator and a high pressure in the condenser.
- **Process 2 - 3:** In the condenser, the refrigerant condenses at high (in relative terms) pressure and temperature while rejecting energy to the water flowing through the coil. Thus the water is heated, producing the heat pump effect. Heat transfer between the condenser and the surrounding air can be estimated as $0.8(T_{air} - T_{evap})$ in Watts.
- **Process 3 - 4:** The high pressure liquid leaves the condenser through a float controlled expansion valve. The pressure drop in the valve causes some of the liquid to flash into vapour, resulting in a two-phase flow which can be observed through the sight-glass located along the return line to the evaporator.
- **Process 4 - 1:** In the evaporator, the refrigerant boils at low pressure and temperature while removing energy from the water flowing through the coil. Thus, the water is chilled, producing the *refrigeration* effect. Heat transfer between the evaporator and the surrounding air can be estimated as $0.8(T_{air} - T_{evap})$ in Watts.

THE TASK:

Using the attached table of "OBSERVATIONS", record the room temperature and pressure, and all instrument readings after the unit stabilizes at *arbitrarily* chosen water flow rates between 5 gm/s and the maximum available amount.

1. Calculate the COP (=benefit/penalty) of the unit as a Refrigerator and as a Heat Pump. State your assumptions clearly.

2. Calculate the mass flow rate, m, of the refrigerant. State your assumptions clearly.

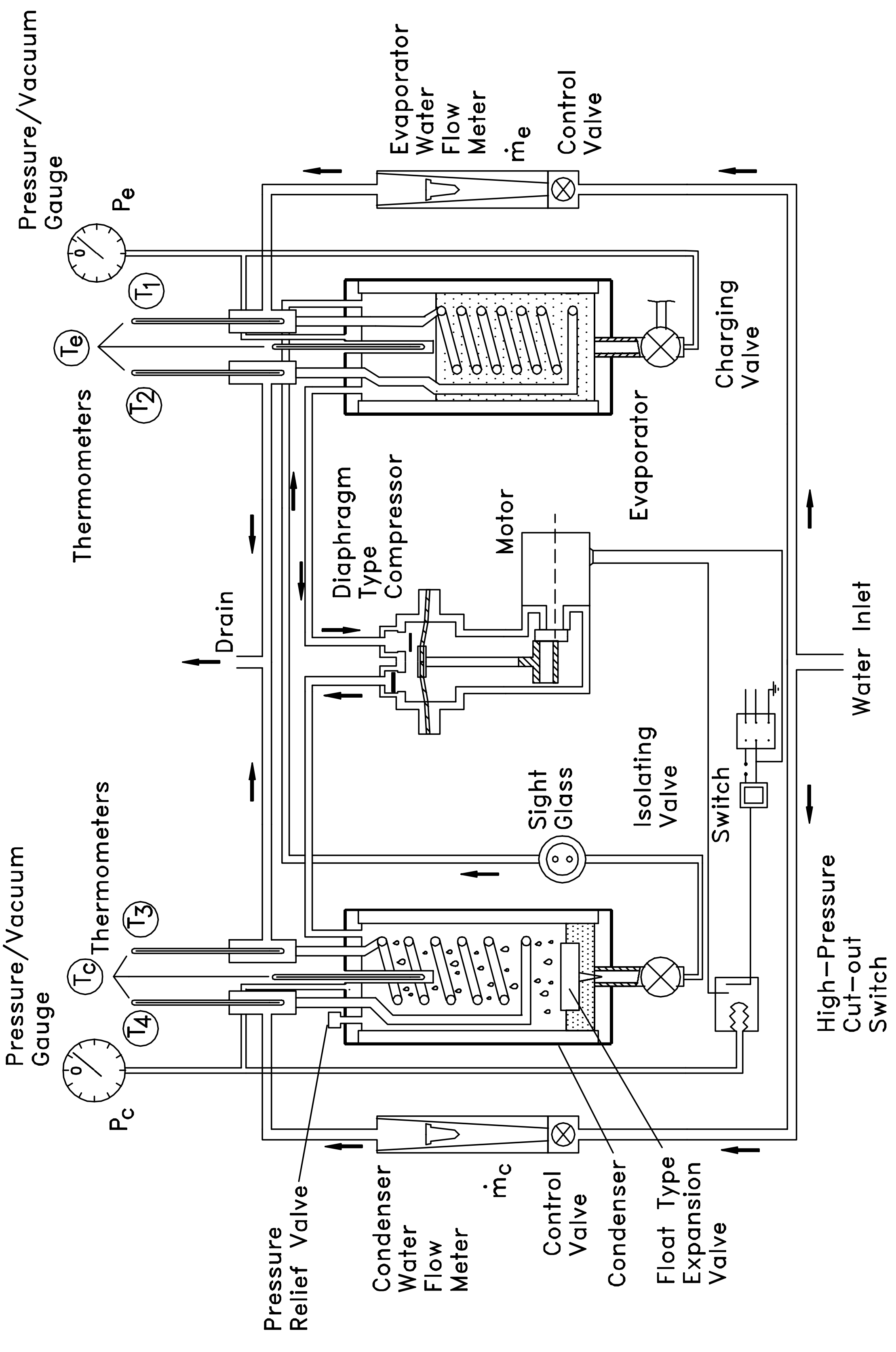
3. Determine P, h and T values for all states 1-4, and show the cycle on a neatly drawn p - h diagram.

4. Submit a hand-written lab report (**INDIVIDUALLY WRITTEN**) not exceeding 10 pages cover-to-cover. Show your analysis very clearly.

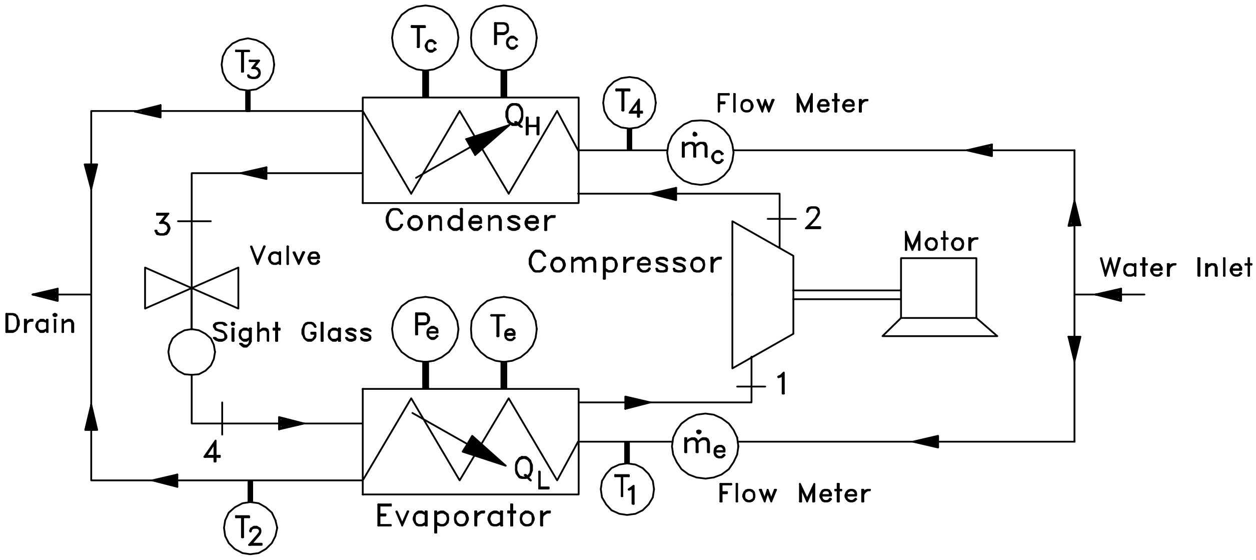
OBSERVATIONS:

Room Temperature (T_a)	=	______	$^\circ C$
Barometer (mbar)	=	______	kNm^{-2}
Electrical power to run the compressor motor			
Voltage	=	______	V
Current	=	______	A

Test No.	1
Evaporator Gauge Pressure, P_e $(kN \cdot m^{-2})$	
Evaporator Temperature, T_e $(^\circ C)$	
Evaporator Water Flow Rate, $\dot{m}_e$ $(gm \cdot s^{-1})$	
Evaporator Water Inlet Temp., T_1 $(^\circ C)$	
Evaporator Water Outlet Temp., T_2 $(^\circ C)$	
Condenser Gauge Pressure, P_c $(kN \cdot m^{-2})$	
Condenser Temperature, T_c $(^\circ C)$	
Condenser Water Flow Rate, $\dot{m}_c$ $(gm \cdot s^{-1})$	
Condenser Water Inlet Temp., T_4 $(^\circ C)$	
Condenser Water Outlet Temp., T_3 $(^\circ C)$	



Refrigeration Cycle Demonstration



Schematic Diagram