Birla Institute of Technology and Science, Pilani

BITS F111 THERMODYNAMICS

First Semester, 2022-23 **MID SEM (Open Book)**

Date : 05/01/2023 Max. Marks: 90 Max. Time: 90 min.

- The Question paper has two parts: **Part A** and **Part B**
- Answer **Part A** in **question paper** itself in the space provided.
- Answer **Part B** in the main **answer book**.
- **Submit A and Part B** separately.
- State and underline the assumptions you make.

ID No. **Name**

PART-A

Q.1a The temperature of a certain monoatomic gas of unknown mass contained in a rigid box falls by 20 °C by losing five kJ of heat. What amount of heat should be transferred (kJ) to raise the temperature of the gas by 19 °C? Solve using the first law of thermodynamics. [5M]

Q.1b Water is contained in a rigid container at 22.12 MPa and 647.3 K. It is cooled to a pressure of 400 kPa. Calculate the final quality. [5M]

Q.2a A sealed steel container contains water at a temperature of 80 °C with a quality of 0.497038. To what temperature (in °C) should it be heated so as to get saturated vapor in the final state? [5M]

Q.2b 10 kg of R-410A at 20 °C is contained in a rigid steel pot with a volume of 0.125 m^3. Heat is now supplied to the tank. What will happen to the level of the R-410A? Justify. [5M]

Q.3a A pump increases the water pressure from 100 kPa at the inlet to 10 MPa at the outlet. Water enters this pump at 20 °C through a 1 cm diameter opening and exits through a 2 cm diameter at the same temperature. Determine the velocity of the water at the inlet and outlet when the mass flow rate through the pump is 0.5 kg/s. [5M]

Q.3b A vertical piston-cylinder system containing a pure substance has an electric heater inside it. The mass of the piston is 10 kg, and it is exposed to atmospheric pressure of 101 kPa. A current of 3 A is supplied to the heater from a 300 V power supply for 5 min; as a result, the piston moves through a distance of 0.5 m. Determine the net work transfer for the system (kJ). The piston is frictionless, with a cross-sectional area of 0.6 m^2. Comment on the nature of work. [5M]

Birla Institute of Technology and Science, Pilani

BITS F111 THERMODYNAMICS

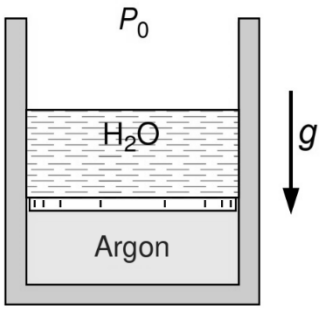
First Semester, 2022-23 **MID SEM (Open Book)**

Date : 05/01/2023 Max. Marks: 90 Max. Time: 90 min.

- Answer **Part B** in the **main answer book**.
- **Submit part A and part B** separately.
- **State and underline the assumptions you make.**

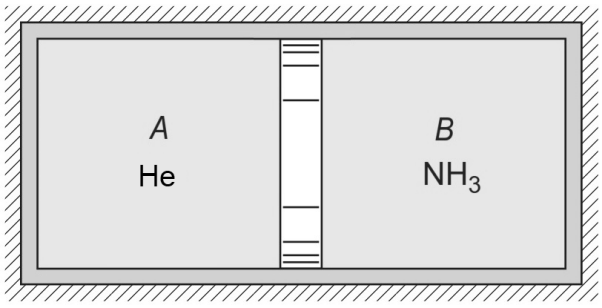
PART-B

Q.4. A 15 m high cylinder with a cross-sectional area of 0.6 m^2 contains 3 m^3 of liquid water at 25 °C on top of the piston and has 1.5 kg of argon at 15°C, with a volume of 3 m^3 below the thin insulated piston of mass 20 kg as shown in the figure. Heat is supplied to the argon such that the piston rises and pushes the water out over the top edge. Find a) the work done to remove the whole water from the top of the piston (kJ), b) the heat transfer to the argon during the process (kJ), and c) plot the process in a *P-v* diagram for the argon. Assume atmospheric pressure as 101 kPa and ignore piston thickness. [20M]



Q.5. An air conditioner supplies cold air to cold storage. Air enters the evaporator section (heat exchanger) of the air conditioner of a cross-sectional area 200 mm x 300 mm at 101.3 kPa and 26.85 °C (state 1) with a velocity of 95 m/min. The exit velocity of air from the evaporator is 30 m/min (state 2). Refrigerant-134a at -20 °C with a quality of 30 percent (state 3) enters the evaporator at a rate of 1.77 kg/min and leaves as saturated vapor (state 4) at the same temperature. Determine (a) the mass flow rate of air (kg/s), (b) the exit temperature of the air (K), and (c) the rate of heat transfer by the air (kW). Neglect the velocity of the refrigerant. *If suitable, the property values for air can be rounded off to the closest value to avoid interpolations from the table.* [20 M]

Q.6. An insulated cylinder is divided into two parts by an insulated frictionless piston, as shown in the figure. Side A has 2 kg of helium at 325 K, 6.192 m^3/kg. Side B has 12.55531 kg of ammonia at -35 °C. Energy is supplied to the ammonia through an electric heater such that ammonia expands and slowly compresses the helium to a pressure of 600 kPa. The compression of helium follows a process with an index of 1.667. Find a) the volume (m^3) of helium in the final state, b) work done by ammonia (kJ), and c) the final temperature of ammonia (°C). [20 M]



If suitable, the property values for ammonia can be rounded off to the closest value to avoid interpolations from the table.

***** BEST WISHES *****