Problems completed by Levi Lentz

Problem 36

A rigid chamber contains 100 kg of water at 500 kPa, 100oC. A paddle wheel stirs the water at 1000 rpm with a torque of 100 N.m. while an internal electrical resistance heater heats the water, consuming 10 amps of current at 110 Volts. Because of thin insulation, the chamber loses heat to the surroundings at 27oC at a rate of 1.2 kW. Determine (a) the rate of shaft work transfer in kW, (b) the electrical work transfer in kJ in 10 s, (c) what must be the rate of heat transfer in kW so that the system does not receive or lose any net energy? (You must include sign).

Solution Find work transfer across the boundary

Assumptions The volume of the chamber remains constant, the work transfer remains constant as stated.

Analysis Since the energy transfer due to the shaft and electrical work are independent of the heat transfer as well as the heat loss to the environment, we can find these to solve for (c).

(a)

With sign

(b)

With sign

(c)

Energy coming in by work:

+1.1 = 11.57kW

Problem 37

An insulated piston-cylinder device contains steam at 300 kPa, 200 deg-C, occupying a volume of 1 m3, and having a specific volume of 0.716 m3/kg. It is heated by an internal electrical heater until the volume of steam doubles due to an increase in temperature. (a) Determine the final specific volume of steam in m3/kg. (b) If the diameter of the piston is 20 cm and the outside pressure is 100 kPa, determine the mass of the weight placed on the piston to maintain a 300 kPa internal pressure. (c) Calculate the boundary work (magnitude only) done by the steam in kJ. (d) Calculate the amount of work (magnitude only) transferred into the weight in kJ. (e) If you are asked to choose one of the three values - 1300 kJ, 300 kJ, 200 kJ - as your guess for the magnitude of the electrical work transfer, which one will you pick? (enter magnitude only).

100kPa

Steam

Solution Use the free body diagram and accompanying information to deduce the formulas required for a-e

Assumptions No heat is lost to the surroundings due to the insulation and the mass of the system is constant

Analysis The solutions can be determined by examining the free body diagram of the piston

a)

Final Volume = and

b)

mg/1000

From the free body diagram of the piston:

c)

b

f

*P*

*~~V~~*

d)

The weight is displaced upward by a distance of

The work done:

e)

Since the steam temperature increases, it must be receiving more energy from the heater than it is delivering through work (300kJ). So my pick is 1300kJ

Problem 33

O2 : 2kg

H2 : 2 kmol

A chamber contains a mixture of 2 kg of oxygen and 2 kmol of hydrogen. (a) Determine the average molar mass of the mixture in kg/kmol. (b) If the specific volume of the mixture is 2 m3/kg, determine the volume of the chamber in m3.

(2.9, 11.9) 10+10

Solution Use the relationship between molar mass to convert the given measurements to a single mass

Assumptions The mass and volume of the system remain unchanged

Analysis From the chemical definition of oxygen gas and hydrogen gas, we can determine the mass of the system.

Mass of O2 = 2 kg

Mole of O2 =

Mole of H2 = 2 kmol

Mass of H2:

For the mixture:

a)

b)

Since:

Problem 34

The nutrition label on a granola bar, which costs $1.00, reads - Serving size 42 g; Calories Per Serving 180. Determine (a) the heating value in MJ/kg, and (b) price in cents per MJ of heat release. (c) If gasoline with a heating value of 44 MJ/kg and a density of 750 kg/m3 costs $2.50 a gallon, what is the gasoline price in cents/MJ?

(18, 132, 2) 10+5+10

Solution Use the definition of heating value as well as fluids definitions to obtain the proper units.

Assumptions The values are not changing with time

Analysis We must use our intuition to determine the proper values, using mainly unit analysis

Heat released from kJ

a)

Heating Value =

b)

Heat released from a bar

Price per MJ:

c)

Mass of a gallon:

Problem 35

(a) What is a system with no mass transfer called?

(b) What is a system with no heat transfer called?

(c) What is a system with no mass or energy transfer called?

Solution Use the generic system diagram with the definition of thermodynamics terms to solve the problem

Assumptions The system is at steady state

a)

No mass transfer:

b)

No heat transfer:

c)

No mass or heat transfer: