Chapter 17 Temperature and Heat (Homework)

Suggested Problems:

1. 25 grams of water at 100 °C is added to 15 grams of water at 20 °C. Calculate the final temperature of the system.

   Ans. 70.0 °C

2. 300 grams of water at 100 °C is added to a 200 gram aluminum container at 20 °C. Calculate the final temperature of the system.

   Ans. 90.0 °C

3. How much 20 °C water must be added to a 750 gram copper container for the equilibrium temperature of the system to be 75 °C? The initial temperature of the copper is 225 °C.

   Ans. 189 grams

4. A 50 gram cube of ice at 0 °C is added to 600 grams of water initially at 23 °C. What is the system's final temperature?

   Ans. 15.1 °C

5. 10 grams of 100 °C steam is added to 50 grams of – 20 °C ice. (a) Calculate the final temperature of the system. (b) How much ice is left un-melted? (c) How much water is left? (d) How much steam is left un-condensed?

   Ans. (a) 31.9 °C (b) 0 grams (c) 60 grams (d) 0 grams

6. 10 grams of 100 °C steam is added to 100 grams of – 20 °C ice. (a) Calculate the final temperature of the system. (b) How much ice is left un-melted? (c) How much water is left? (d) How much steam is left un-condensed?

   Ans. (a) 0 °C (b) 32.3 grams (c) 0 grams (d) 0 grams

7. How much heat is lost per hour though a 1.5 m^2 glass window that is 0.75 cm thick if the inside temperature is 20 °C and the outside temperature is 0 °C . (The thermal conductivity of glass is 0.8 W/m °C)

   Ans. 1.15×10^7 J

Challenging Problems:

1. A 200 gram copper container holds 100 grams of water and a 15 gram ice cube. Initially they are all at 0 °C. After a 500 °C piece of lead is dropped into the water the equilibrium temperature is 20 °C. What was the mass of the lead added to the system?

   Ans. 278 grams

Chapter 18 Thermal Properties of Matter (Homework)

Suggested Problems:

1. Two moles of nitrogen gas are at STP. If the gas is heated at a constant volume until its temperature doubles, what is its new pressure?

   Ans. 2.02×10^{5} N/m ^{2}

2. A room has dimensions of 10 m by 15 m by 3 m. If the air temperature is 25 °C and its pressure is 1 atm, how many gas molecules are there in the room?

   Ans. 1.11×10^{28} molecules

3. If 5 grams of water vapor are contained in a tank at STP, what is the new temperature if the gas pressure is raised to 2 atm?

   Ans. 546 K

4. The gas in a 1.5 liter container has a temperature of 22 °C and a pressure of 5 atm. If the temperature of the gas is raised to 100 °C what is the new pressure?

   Ans. 6.39×10^{5} N/m ^{2}

5. How many moles of an ideal gas are contained in a 3 liter bottle at 127 °C and 4 atmospheres of pressure?

   Ans. 0.365 moles

6. A balloon is filled with 1 mole of gas at a temperature of 23 °C and a pressure of 9.95×10^{4} N/m ^{2}. The balloon is then submerged to a depth where the new temperature is 18 °C and the pressure is 2.00×10^{5} N/m ^{2}. What is the volume of the balloon (a) before and (b) after being submerged?

   Ans. (a) 0.0247 m ^{3} (b) 0.0121 m ^{3}

7. During a storm 750 hailstones strike a 2 m^{2} window in one minute. If the collisions are elastic and the hail strikes at a 45° angle what is (a) the average force and (b) the pressure exerted on the window? The average hailstone has a mass of 10 grams and a speed of 15 m/s.

   Ans. (a) 2.65 N (b) 1.33 N/m ^{2}

8. A 10 liter vessel contains helium gas at 23 °C and 2 atmospheres of pressure. (a) Calculate the rms speed of the molecules, (b) the average kinetic energy per molecule and (c) the total kinetic energy of the gas.

   Ans. (a) 1360 m/s (b) 6.13×10^{-21} J (c) 3030 J

9. Calculate (a) the rms speed of the oxygen molecules in the atmosphere if the temperature is 27 °C. (b) Calculate the rms speed of the nitrogen molecules in the air at the same temperature.

   Ans. (a) 483 m/s (b) 517 m/s

10. 2 moles of a monatomic gas initially at STP are heated at a constant pressure until the temperature triples. Calculate (a) the change in heat (b) the change in internal energy and (c) the work done by the gas.

    Ans. (a) 2.27×10^{4} J (b) 1.36×10^{4} J (c) 9.07×10^{3} J

11. Calculate the change in internal energy of 5 moles of a monatomic gas initially at STP when the temperature changes by 10 °C.

    Ans. 623 J

12. 1 mole of a diatomic gas at STP is heated at a constant pressure until its volume triples and then it is heated at constant volume until its pressure doubles. How much heat was added to the gas?

    Ans. 3.29×10^{4} J

Challenging Problems:

1. 10 liters of a diatomic gas start at STP (this is state 1). First its pressure is increased to 5 atm at a constant volume (this is state 2); then it expands isothermally until its pressure is 3 atm (this is state 3). Next it expands adiabatically until its pressure returns to 1 atm (this is state 4) and finally it is compressed isobarically until its volume is again 10 liters (this is state 1). (a) Calculate the temperature at states 2, 3, and 4. (b) Calculate the change in heat for each of the four processes. (c) Calculate the change in internal energy for each of the four processes. (d) Calculate the work done by the gas for each of the four processes.

   Ans. (a) 273 K, 1360 K, 1360 K, 1040 K (values to 3 sig fig)
   Ans. (a) 273 K, 1365 K, 1365 K, 1037 K (values used in following calculations)
   Ans. (b) 1.21×10^{4} J, 0 J, -3.64×10^{3} J, -8.48×10^{3} J
   Ans. (c) 1.21×10^{4} J, 2.58×10^{3} J, 0 J, -1.13×10^{4} J
   Ans. (d) 0 J, 2.58×10^{3} J, 3.64×10^{3} J, -2.82×10^{3} J

Chapter 19 First Law of Thermodynamics (Homework)

Suggested Problems:

1. In one thermodynamic process the relationship between pressure and volume is given by $P = \alpha V^{2}$, where $\alpha = 4.50$ atm/m^{6}. How much work does the gas do as it expands from 1.50 m^{3} to 3.50 m^{3}?

   Ans. 5.97×10^{6} J

2. 3 moles of monatomic ideal gas at STP are isothermally compressed until the pressure doubles. Determine (a) the initial volume, (b) the work done by the gas and (c) the heat transferred to or from the gas.

   Ans. (a) 0.0674 m^3 (b) – 4720 J (c) – 4720 J

3. A monatomic ideal gas initially at STP expands isobarically from 1 m^3 to 2 m^3. If 1.4×10^5 J of heat is transferred to the gas what are (a) the change in the internal energy and (b) the final temperature of the gas?

   Ans. (a) 3.90×10^4 J (b) 546 K

4. Calculate (a) the total work done per cycle (b) the heat added to the gas per cycle (c) the heat lost by the gas per cycle for the following cycle: P1 = P4 = 1 atm, P2 = P3 = 3 atm, V1 = V2 = 100 L and V3 = V4 = 200 L. There are 4 moles of a monatomic ideal gas.

   Ans. (a) 2.02×10^4 J (b) 1.06×10^5 J (c) 8.59×10^4 J

5. During an adiabatic compression 0.2 moles of a diatomic gas goes from STP to a pressure of 15 atm. Calculate (a) the new volume, (b) the new temperature, (c) the change in heat, (d) the change in internal energy and (e) the work done by the gas.

   Ans. (a) 6.49×10^{-4} m^3 (b) 592 K (c) 0 (d) 1.33×10^3 J (e) -1.33×10^3 J

6. A weather balloon is released from the ground where the temperature is 27 °C. If the balloon rises and expands adiabatically until its volume has increased by a factor of 2, what is the final temperature. (Assume the gas in the balloon is diatomic.)

   Ans. 227 K

Challenging Problems:

None

Chapter 20 Second Law of Thermodynamics (Homework)

Suggested Problems:

1. A heat engine performs 1500 J of work each cycle and is 20 % efficient. (a) Determine how much heat is taken in during each cycle and (b) how heat is exhausted each cycle.

   Ans. (a) 7500 J (b) 6000 J

2. A particular heat engine absorbs 1.5 MJ from the hot reservoir 327 °C and exhausts 1 MJ to the cold reservoir at 27 °C. (a) What is the engine's efficiency? (b) What is the engine's power if each cycle lasts 0.6 seconds? (c) What is the maximum efficiency of an engine operating between these two temperatures?

   Ans. (a) 0.333 (b) 8.33×10^5 w (c) 0.500

3. The hot reservoir of a heat engine is a pool of lead at 327 ^{o}C and its cold reservoir is a block of mercury at – 38.9 ^{o}C. The engine freezes 12 kg of lead each cycle and melts 10 kg of mercury per cycle. Calculate the efficiency of the engine. (Heat of fusion for lead is 2.45×10^{4} J/kg and for mercury is 1.18×10^{4} J/kg)

   Ans. 0.599

4. A Carnot heat engine operates between 27 ^{o}C and 2000 ^{o}C. Determine its efficiency.

   Ans. 0.868

5. A Carnot heat engine operating between 27 ^{o}C and 1200 ^{o}C absorbs 125 kJ per second. (a) Determine its efficiency. (b) What is the engine's power output?

   Ans. (a) 0.796 (b) 9.95×10^{4} w

6. A Carnot engine has an efficiency of 85 % and its cold reservoir is at 27 ^{o}C. Calculate the temperature of its hot reservoir.

   Ans. 2000 K

7. 1 kg of water at 0 ^{o}C freezes slowly and completely without changing temperature. Calculate the change of entropy of the water.

   Ans. – 292 cal/K

8. 25 grams of water at 10 ^{o}C is added to 35 grams of water 90 ^{o}C. (a) What is the final equilibrium temperature of the system? (b) What is the change of entropy for the hot water? (c) What is the change of entropy for the cold water? (d) What is the change of entropy for the system?

   Ans. (a) 56.7 ^{o}C (b) – 3.34 cal/^{o}C (c) 3.84 cal/^{o}C (d) 0.505 cal/^{o}C

9. During an isothermal compression 2 moles of a diatomic gas goes from STP to a pressure of 15 atm. Calculate the change in entropy.

   Ans. – 45.0 J/K

10. During an adiabatic expansion 0.5 moles of a polyatomic gas goes from STP to a pressure of 0.25 atm. Calculate (a) the new volume, (b) the new temperature and (c) the change in entropy.

   Ans. (a) 3.17×10^{-2} m^{3} (b) 193 K (c) 0

Challenging Problems:

1. 1 mole of a diatomic gas start at STP (this is state 1). First its pressure is increased to 4 atm at a constant volume (this is state 2). Next it expands adiabatically until its pressure returns to 1 atm (this is state 3) and finally it is compressed isobarically until it returns to its original volume (this is state 1). (a) Calculate the temperature at states 2 and 3. (b) Calculate the change

in heat for each of the three processes. (c) Calculate the efficiency of the cycle. (d) Calculate the maximum efficiency of the cycle.

Ans. (a) 1090 K, 735 K (b) 1.70×10^4 J, 0 and - 1.34×10^4 J (c) 0.212 (d) 0.750

2. 2 moles of a diatomic gas start at STP (this is state 1). First its pressure is increased to 3 atm at a constant volume (this is state 2). Next it expands isothermally until its pressure returns to 1 atm (this is state 3) and finally it is compressed isobarically until it returns to its original volume (this is state 1). (a) Calculate the temperature at states 2 and 3. (b) Calculate the volume at states 1, 2 and 3. (c) Calculate the change in entropy for each of the three processes. (d) Calculate the change in entropy for the complete cycle.

   Ans. (a) 819 K, 819 K (b) 0.0449 m^3, 0.0449 m^3, 0.135 m^3 (c) 45.6 J/K, 18.3 J/K, – 63.9 J/K (d) 0