CH1020 Exercises (Worksheet 13)
(System, Surroundings, Internal energy, PV work)

1. Suppose that a person eats a diet of 2387 Calories per day. Convert this energy into each unit:
   a. J ***9.987×10^6 J*** b. kJ ***9.987×10^3 kJ*** c. kWh ***2.78 kWh***

2. In a thermodynamic study a scientist focuses on the properties of a solution in a flask that is sealed with a stopper. A. What is the system in this study? B. What are the surroundings in this study? C. Is the system in this study a closed system?
   A. solution is the system
   B. surroundings are the flask, the stopper, the air around the flask and remainder of the universe
   C. the system is closed, because the stopper prevents mass transfer with the surroundings. Energy can be transferred as heat to the flask and other surroundings

3. What is meant by the internal energy of a system? By what means can the internal energy of a system increase?
   The total internal energy(E) of a system is the sum of all the kinetic and potential energies of the system components. The internal energy of a system increases when work is done on the system by the surroundings and/ or when heat is transferred to the system from the surroundings (the system is heated)

4. Can we measure the internal energies of a system? Explain.
   It is very difficult to measure the absolute E of a system because it has so many components. It encompasses the kinetic energy of all moving particles in the system, including subatomic particles, and the electrostatic potential energies between all these particles. It is possible to measure the changes in internal energy (ΔE) when a system undergoes a chemical or physical change.

5. Under what conditions will the quantities q and w be negative numbers?
   The quantities q and w are negative when the system loses heat to the surroundings (it cools) or does work on the surroundings.

6. Identify each energy exchange as primarily heat or work and determine whether the sign of ΔE is positive or negative for the system:
   a. Sweat evaporates from skin, cooling the skin. (The evaporating sweat is the system) ***heat, +***
   b. A balloon expands against an external pressure. (The contents of the balloon is the system.) ***work, -***
   c. An aqueous chemical reaction mixture is warmed with an external flame. (The reaction mixture is the system). ***heat, +***

7. Calculate ΔE and determine whether the process is endothermic or exothermic for the following cases:
   a. a system absorbs 327 kJ of heat from the surroundings and does 430 kJ of work on the surroundings
      ΔE = -103 kJ; endothermic

   b. q = -1.15 kJ and w = -934 J
      ΔE = -2.08 kJ; exothermic

   c. the system releases 245 J of heat while the surroundings does 97 J of work on it
      ΔE = -148 J; exothermic

   d. a balloon is heated by adding 240 J of heat. It expands doing 135 J of work on the atmosphere.
      ΔE = +105 J; endothermic

   e. A 50 g sample of iron metal is cooled from 100°C to 90°C, thereby losing approximately 225 J of heat.
      ΔE = -225 J; exothermic

   f. A chemical reaction releases 5.75 kJ of heat and does no work on the surroundings.
      ΔE = -5.75 kJ; exothermic

8. What is meant by a state function? Is temperature a state function? Why or why not?
   A state function is a property of a system that depends only on the physical state (P, T, etc.) of the system, not on the route used by the system to get to the current state. Internal energy and enthalpy are state functions. Work is not a state function.
   Temperature is a state function, regardless of how hot or cold the sample has been, the temperature depends only on the present condition.

9. Indicate which of the following is independent of the path by which a change occurs?
   a. the change in potential energy when a book is transferred from table to shelf ***Independent; potential energy is a state function***

   b. the heat evolved when a cube of sugar is oxidized to $CO_2(g)$ and $H_2O(g)$
      dependent; some of the energy released could be employed in performing work, as is done in the body when sugar is metabolized; heat is not a state function

   c. the work accomplished in burning a gallon of gasoline

dependent; the work accomplished depends on whether the gasoline is used in an engine, burned in an open flame, or in some other manner. Work is not a state function.

10. Predict the signs of q and w for the process of boiling water.

$H_2O_{(l)} \rightarrow H_2O(g)$

Heat must be added for boiling, so q is positive

Gas occupies larger volume, expansion, w is negative; system does work on surroundings

11. Calculate ΔE for each of the following:
    a. q = -47 kJ, w = + 88kJ
       41 kJ
    b. q = +82 kJ, w = +47 kJ
       129 kJ
    c. q = +47 kJ, w = 0
       47 kJ
    d. In which of these cases do the surroundings do work on the system?
       When w is positive, for a and b

12. A system undergoes a process consisting of the following two steps:
    Step1: The system absorbs 72 J of heat while 35 J of work is done on it
    Step 2: The system absorbs 35 J of heat while performing 72 J of work
    Calculate ΔE for the overall process.
    70. J

13. The volume of an ideal gas is decreased from 5.0 L to 5.0 mL at a constant pressure of 2.0 atm. Calculate the work associated with this process.
    1.0×10^3 J

14. How much work (in J) is required to expand the volume of a pump from 0.0 L to 2.5 L against an external pressure of 1.1 atm?
    -2.8×10^2 J

15. Consider a mixture of air and gasoline vapor in a cylinder with a piston. The original volume is 40. cm^3. If the combustion of this mixture releases 950. J of energy, to what volume will the gases expand against a constant pressure of 650. torr if all the energy of combustion is converted into work to push back the piston?
    11.0 L

16. To inflate a balloon pressure-volume work is done on the surroundings. If 177 J of work was used to inflate a balloon from an initial volume of 0.100 L against an external pressure of 1.00 atm, what is the final volume of the balloon?
    1.85 L