Worksheet 3

January 18, 2022

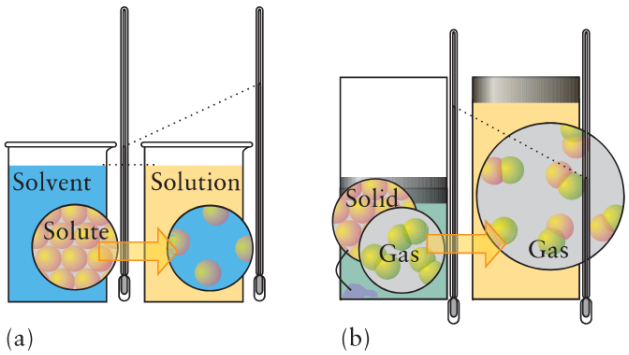
Weekly homework assignments are posted approximately one week prior to the due date. Collaborations are encouraged and students must report all collaborators in writing on each assignment. All external sources (websites, books) must be properly cited. Additional problems are listed at the end of each assignment. This week's assignment is due *Tuesday, Jan 25th at 10:00am.*

Real Gas

1. (2 pts) The pressure of a sample of hydrogen fluoride is lower than expected and, as the temperature is increased, rises more quickly than the ideal gas law predicts. Suggest an explanation in words and/or illustrations.

First Law of Thermodynamics

2. (2 pts) Below there are pictures showing a molecular view of a system undergoing a change. In each case, predict the signs of q and w for each process. Explain what is happening to the system.



Enthalpy ΔH

3. (4 pts) Carbon disulfide can be prepared from coke (an impure form of carbon) and elemental sulfur

$$4\ \mathrm{C(s)} + \mathrm{S_8(s)} \rightarrow 4\ \mathrm{CS_2(l)} \quad \Delta H_r = +358.8\mathrm{kJ}.$$

(a) How much heat is absorbed in the reaction of 1.25mol S_8?

(b) Calculate the heat absorbed in the reaction of 197g of carbon with an excess of sulfur.

(c) If the heat absorbed in the reaction was 415kJ, how much of CS_2 was produced?

4. (4 pts) Calculate the heat generated by a reaction mixture of 13.4L of SO_2 at 1.00atm and 273K and 15.0g of oxygen in the reaction

$$2\ \mathrm{SO_2(g)} + \mathrm{O_2(g)} \rightarrow 2\ \mathrm{SO_3(g)} \quad \Delta H_r = -198\mathrm{kJ}.$$

5. (4 pts) An experimental automobile burns hydrogen for fuel. At the beginning of a test drive, the rigid 30.0-L tank was filled with hydrogen at 16.0atm and 298K. At the end of the drive, the temperature of the tank was still 298K, but its pressure was 4.0atm.

(a) How many moles of H_2 were burned during the drive?

(b) How much heat, in kilojoules, was given off by the combustion of that amount of hydrogen?

6. (8 pts) **Carbon footprint of a hot bath** A standard bathtub has a volume of approximately 80 gallons. Assume that you fill up your tub with water heated to 100°F for a nice hot bath. A typical temperature of cold water supplied by the city is 50°F. Report to 3 significant figures.

(a) Determine the amount of heat (in kJ) required to heat up the water.

(b) The heat is generated by a natural gas water heater with approximately 70% efficiency. For the present purpose, we assume that natural gas consists entirely of methane. Using tabulated standard enthalpies of formation of methane ($\Delta H_f^\circ = -74.6\text{kJ/mol}$) and carbon dioxide ($\Delta H_f^\circ = -393.5\text{kJ/mol}$), calculate the amount of CO_2 in g emitted by the water heater.

(c) Cold potable water sourcing, treatment, and transportation to your home has a carbon footprint of approximately 4g CO_2 per gallon of water. Estimate the total carbon footprint (i.e. grams of CO_2 produced) of a hot bath by adding the footprints of cold potable water and water heating.

d) A sustainable carbon footprint is 2 (metric) tons per person per year. Assuming you do not want to spend more than 1% of your carbon budget on bathing, how many hot baths can you take per month at the most?

Optional Additional Problems: Ch. 9 - odd problems 31 - 69