Week 8 Worksheet

Chem 11100-2: Section 33

Nov. 16, 2021

Remarks: The following information might be useful

1. The specific heat capacity of water is 4.184 J/g°C
2. The specific heat capcacity of Fe is 0.449 J/g°C
3. Molar heat of solution for $KClO_3$ in water, $\Delta H_{soln} = 41.38$ kJ/mol
4. 760 mm Hg = 1 atm

Bond	Energy [kJ/mol]
N−N	946
H−H	436
N−H	389

Table 1: Bond Energies given in kJ/mol

***Problem* 1:** A sealed balloon has a volume of 2.00 L in a 5.00°C freezer. Calculate the work involved when the gas inside the balloon (in units of L·atm) is heated to a temperature of 90.0°C at constant pressure of 735 mm Hg. Explain the sign of your final answer and whether it makes sense.

***Problem* 2:** The process of dissolving $KClO_3$ in water has a molar heat of solution, given in the table above. What change in temperature would you predict for the process of dissolving 0.1375 grams of $KClO_3$ in 20.00 grams of water?

***Problem* 3:** How much heat energy will be released when 1.48 grams of Cl_2 (g) reacts based on the following reaction? ($\Delta H_{rxn} = -443kJ$ per mole of PCl_5 formed)

$$\mathrm{P\ (s) + Cl_2\ (g) \longrightarrow PCl_5\ (g)}$$

***Problem* 4:** A chemist reacts hydrogen gas with nitrogen gas to form ammonia (NH_3).

a) Using bond energies, estimate the enthalpy change as a result of this process.

b) The actual, experimentally-determined change in enthalpy for this reaction is −92.4 kJ/mol. Based on this, calculate the true bond energy of each N−H bond in a molecule of ammonia.

c) Explain why the true bond energy of an N−H bond in a molecule of ammonia is not equal to the bond energy listed for an N−H bond in the table of values.

d) Is an N−H bond in ammonia stronger or weaker than an average N−H bond? Why?

e) Calculate the amount of heat energy involved in the reaction of exactly 1.00 g of hydrogen gas with excess nitrogen gas in this reaction. Clearly indicate with words or the sign of your answer the direction of heat flow as a result of this process.

The following are good review problems for the midterm Friday.

***Problem* 5:** The chemistry of airbags involves the rapid decomposition of solid sodium azide (NaN_3). Sodium azide is stable at room temperature but, upon detecting a crash or impact, a car's sensors will initiate a quick ignition to promote the decomposition of the compound into its respective neutral elemental forms. One of the products is a gas, which when produced, inflates the airbag.

So that the sodium product of this reaction does not react violently with water in the air, solid potassium nitrate (KNO_3) is included in airbags to instantly react with elemental sodium. The products of this second reaction are solid sodium oxide, solid potassium oxide, and nitrogen gas.

a) Write balanced molecular equations for the two chemical reactions described above.

b) An average driver's side airbag fully inflates to a total volume of 60.0 liters. How many grams of sodium azide would initially be required at STP to produce enough N_2 to fully inflate the airbag?

c) Why might airbags not work ideally in extreme cold temperature conditions?

d) The heat of formation, ΔH_f for sodium azide is 21.3 kJ/mol. Based on this, would you expect the gas in the airbag to become hotter or colder than the average air in the car? Explain why.

***Problem* 6:** Imagine you have 15.0 g of 30.°C pure water. What mass of each of the following substances could independently be added to this water to change the initial water's temperature by exactly 15.0°? In each case, assume the added substances ends up at the same final T as the water.

a) 90.°C solid iron metal

b) 30.°C solid potassium chlorate