

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

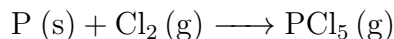
Bond	Energy [kJ/mol]
N–N	946
H–H	436
N–H	389

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? ($\Delta H_{\text{rxn}} = -443 \text{ kJ}$ per mole of PCl_5 formed)



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