Chemistry 2740 Spring 2018 Test 1

Time: 50 minutes
Marks: 29
Aids allowed: calculator, 8.5×11-inch formula sheet
Useful data is given on the reverse of this page.
Instructions: You can answer the questions in any order, but make sure that you clearly label each of your answers with the question number in your exam booklet(s).

1. One way your body keeps you cool when it's hot is to sweat. Heat is removed by evaporation of the water from the sweat.

   (a) Suppose that 120 g of water evaporates off your body per hour during exercise, or on a hot day. (This is a typical figure for an average sized person exercising vigorously, but would depend on many factors, including the relative humidity, the temperature, etc.) How much heat is removed per hour? The enthalpy of vaporization of water at 32 °C, a typical skin temperature during exercise, is $2427\,\mathrm{J\,g^{-1}}$. [2 marks]

   (b) To put this number in perspective, suppose that you did not sweat and that this heat was trapped within the body. How much would the temperature of a 74 kg athlete rise in one hour if this were the case? The specific heat capacity of the human body is approximately $3.47\,\mathrm{J\,K^{-1}g^{-1}}$. [2 marks]

2. Deuterium oxide (D_2O, "heavy water") melts at 276.83 K.[1] The entropy of deuterium oxide ice at this temperature is $43.37\,\mathrm{J\,K^{-1}mol^{-1}}$, and the enthalpy of fusion is $6.132\,\mathrm{kJ\,mol^{-1}}$.

   (a) What is the entropy of liquid deuterium oxide at the melting point? [4 marks]

   (b) The heat capacity of the liquid is well fit by the equation

   $$C_{p,m} = A + BT + C/T,$$

   where

   $$A = -91.35\,\mathrm{J\,K^{-1}mol^{-1}},$$
   $$B = 0.2628\,\mathrm{J\,K^{-2}mol^{-1}},$$
   $$C = 28\,777\,\mathrm{J\,mol^{-1}}.$$

   Calculate the standard entropy (at 298.15 K) of liquid deuterium oxide. [8 marks]
   Hint: $1/x^n = x^{-n}$.

[1] All data in this problem is from N. N. Smirnova et al., *J. Chem. Thermodynamics* **38**, 879 (2006).

3. A 1.1041 g sample of palmitic acid ($C_{16}H_{32}O_2$, solid at room temperature, molar mass $256.428\,g\,mol^{-1}$) was burned in a bomb calorimeter with a heat capacity of $11.08\,kJ\,K^{-1}$. 9.8 cm of fuse wire with a (constant-volume) heat of combustion of $-9.6\,J\,cm^{-1}$ was used to ignite the sample. A temperature increase of 3.879 K is recorded. Calculate the standard enthalpy of formation of palmitic acid. Assume that the experiment is run near 25 °C. [13 marks]

Useful data

Constants and conversion factors

$0\,K = -273.15\,°C$
$R = 8.314\,472\,J\,K^{-1}mol^{-1}$

Standard thermodynamic data at 298.15 K		
Species	$\frac{\Delta_f H^\circ}{kJ\,mol^{-1}}$	$\frac{C_{p,m}}{J\,K^{-1}mol^{-1}}$
$CO_{2(g)}$	−393.51	37.1
$H_2O_{(l)}$	−285.830	75.40
$O_{2(g)}$	0	29.35