

Chemistry 2720 Fall 2005 Test 1

Time: 75 min

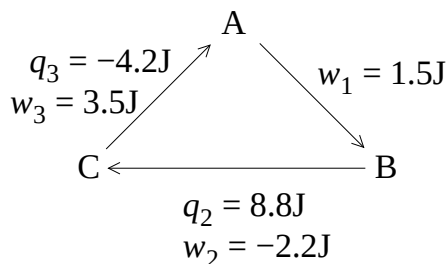
Marks: 54

Aids permitted: calculator, one 8.5×11 -inch formula sheet

Write all answers in the booklets provided.

Useful data is given at the end of this exam paper.

1. Consider the following cyclic process connecting three states A, B and C:



- What is q_1 , the heat evolved in the process $A \rightarrow B$? Explain in a few words the key ideas behind your solution. [7 marks]
2. 0.53 mol of an ideal gas initially at a temperature of 300 K and at a pressure of 1.8 bar is expanded isothermally in three steps. In each step, the pressure is dropped suddenly and held constant until equilibrium is reestablished. The pressures at each of the three stages of expansion are 1.4, 1.0 and 0.7 bar.
- (a) Calculate the work done in this process. [11 marks]
- (b) Would more or less work be done by the gas if the expansion had been done in a single step? Explain briefly. [6 marks]
3. Scientific research labs often have -60°C freezers which are used to preserve biological samples. Biological samples are mostly aqueous, so their thermal properties can be approximated by those of water. Suppose that 200 g of samples are placed in a -60°C freezer. The samples are initially at room temperature (20°C). What is the minimum electrical work which the freezer will have to perform in order to bring the samples to the freezer's set-point temperature? [8 marks]
4. Tetrachloromethane (CCl_4) boils at 349.7 K and has an enthalpy of vaporization of 30.0 kJ/mol at that temperature. The constant-pressure heat capacity of the vapor is $83.3 \text{ J K}^{-1} \text{ mol}^{-1}$. Calculate accurately the standard enthalpy of formation of gaseous tetrachloromethane at 298.15 K. [10 marks]

5. Room C640 has a capacity of 64 students, and the Chemistry 2720 enrollment in Fall 2005 is 43. Assuming that students choose seats randomly, what is the entropy of the possible seating arrangements? Express your answer in terms of k_B . [5 marks]
6. As mentioned in class, old thermodynamics tables used 1 atm as their standard pressure.
- (a) Derive an equation to adjust entropies of gases at the old standard pressure to entropies at the new standard pressure of 1 bar. Assume ideal gas behavior. [5 marks]
 Hint: What is the change in entropy of a gas whose pressure is changed isothermally from 1 atm to 1 bar?
- (b) The standard entropy of $\text{ClF}_{3(g)}$ in the old convention is $281.5 \text{ J K}^{-1}\text{mol}^{-1}$. Calculate the standard entropy of this compound in the new standard state. [2 marks]

Useful data

$$\begin{aligned} 1 \text{ atm} &= 101\,325 \text{ Pa} \\ 1 \text{ bar} &= 100\,000 \text{ Pa} \\ \text{To convert degrees Celsius to Kelvin, add } 273.15. \end{aligned}$$

$$R = 8.314\,472 \text{ J K}^{-1}\text{mol}^{-1}$$

$$\begin{aligned} \text{Enthalpy of fusion of ice} &= 333.4 \text{ J/g} \\ \text{Specific heat capacity of ice} &= 2.113 \text{ J K}^{-1}\text{g}^{-1} \\ \text{Specific heat capacity of liquid water} &= 4.184 \text{ J K}^{-1}\text{g}^{-1} \end{aligned}$$

Species	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	C_P (J K ⁻¹ mol ⁻¹)
$\text{CCl}_{4(l)}$	-129.6	-65.2	131.8