

Epsilite Team
The National Higher School of Autonomous Systems

Chemistry Exercises: Thermodynamics

Part 1: Ideal Gas Laws

- **Q1:** A cylinder with a piston contains 540 cm^3 of O_2 gas at $P = 63.3 \text{ kPa}$. If the volume changes to 325 cm^3 for the same mass at **constant temperature**, find the final pressure (P_2).
- **Q2:** A 10 L **rigid** container is filled with gas at 1 atm and 25°C . What is the pressure if it is heated to 75°C ?
- **Q3:** A gas sample occupies 10 L at 24°C and 80 kPa . If it is placed in a cylinder and the pressure increases to 107 kPa with an expansion in volume to 20 L , calculate the final temperature (T_2).

Part 2: Calorimetry and Heat Capacity

Exercise 1

1. A calorimeter contains a mass of water $m = 200 \text{ g}$ at temperature $\theta_1 = 15.1^\circ\text{C}$. We add the same mass of water at $\theta_2 = 52.3^\circ\text{C}$. The equilibrium temperature is $\theta_{eq} = 32.4^\circ\text{C}$.
 - Establish the calorimetric equation for the system (water + calorimeter) and deduce the heat capacity C of the calorimeter.
2. Two metal blocks of $m = 300 \text{ g}$ (Aluminum and Nickel):
 - In a calorimeter with negligible heat capacity, we introduce $m_{water} = 200 \text{ g}$ at $\theta_0 = 18^\circ\text{C}$.
 - Each block is heated to $\theta = 90^\circ\text{C}$ before being placed in the calorimeter.
 - Equilibrium temperatures: $\theta_{Al} = 35.5^\circ\text{C}$ and $\theta_{Ni} = 27.9^\circ\text{C}$.
 - Find the specific heat capacity ($J \text{ K}^{-1}\text{kg}^{-1}$) for each material, then deduce their molar heat capacity.

Constants: $c_{water} = 4185 \text{ J K}^{-1}\text{kg}^{-1}$; $M_{Al} = 26.98 \text{ g/mol}$; $M_{Ni} = 58.70 \text{ g/mol}$.

Part 3: Nitrogen Gas and Phase Change

Exercise A (Nitrogen Bottle)

A bottle (1.8 L) is filled with N_2 at $T_1 = 10^\circ\text{C}$ and $P_1 = 100 \text{ bar}$.

1. Calculate the mass of Nitrogen gas present in the bottle.
2. What is the new pressure when the temperature becomes $T_2 = 38^\circ\text{C}$?
3. To keep $P = 100 \text{ bar}$ at $T = 38^\circ\text{C}$, what mass of N_2 must be released?

Exercise B (Ice Cube Transformation)

An ice cube with a mass of $m = 50 \text{ g}$ is initially at a temperature of $T_{initial} = -10^\circ\text{C}$. Calculate the total amount of heat (Q_{total}) required to transform this ice cube completely into a liquid state at a final temperature of $T_{final} = 20^\circ\text{C}$.

Necessary Data for Calculation:

- Specific heat of ice: $c_{ice} = 2100 \text{ J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$
- Latent heat of fusion for ice: $L_f = 334 \times 10^3 \text{ J} \cdot \text{kg}^{-1}$
- Specific heat of liquid water: $c_{water} = 4185 \text{ J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$

Part 4: Calorimetry and Melting Equilibrium

Exercise 2

A calorimeter ($\mu = 20 \text{ g}$) contains 200 g of water at 30°C . We add 100 g of ice at 0°C . The final equilibrium temperature is $T_f = 0^\circ\text{C}$.

1. Calculate the mass of ice that has melted (m_{melted}).
2. Find the mass of the ice remaining in the calorimeter.