

Tutorial Series N°3

Exercise 1

Calculate the change in internal energy of each of the following systems:

- a- A system absorbs $Q = 2$ KJ while supplying work $W = 500$ J to the outside;
- b- A gas maintained at constant volume gives up $Q = 5$ KJ ;
- c- The adiabatic compression of a gas produces work $W = 80$ J.

Exercise 2

One mole of $N_2(g)$, considered as an ideal gas, is heated from $20^\circ C$ to $100^\circ C$.

Calculate :

- a- The amount of heat Q received by this system and its change in internal energy when the transformation is isochore
- b- The amount of heat Q received by this system and its change in enthalpy when the transformation is isobaric.
- c- The gas undergoes a reversible adiabatic expansion from state 1 of volume $V_1 = 2.46$ L to state 2 of volume V_2 .
- d- Calculate V_2 if $P_1 = 10$ atm and $P_2 = 2$ atm.

Data: $C_p(N_2, g) = 33$ J. mol⁻¹ .K⁻¹ and $R = 8.314$ J. mol⁻¹ .K⁻¹

Exercise 3

Calculate the enthalpy change of 10g of ice whose temperature varies from $-20^\circ C$ to $100^\circ C$ under the pressure of one atmosphere.

The heats of mass of the pure substances are given:

$C_p(H_2O, \text{solid}) = 0.5$ cal.g⁻¹ .k⁻¹ $\Delta H_f = 80$ cal g⁻¹ , $\Delta H_v = 539$ cal g⁻¹

$C_p(H_2O, \text{liquid}) = 1$ cal.g⁻¹ .k⁻¹

Exercise 4

One mole of monoatomic ideal gas undergoes the following successive transformations:

- A reversible isothermal compression from an initial state 1 to a state 2
- A reversible adiabatic expansion from state 2 to state 3
- Isobaric heating which returns it to the initial state 1.

- 1) Calculate V_1, V_2, T_2, T_3 if $P_1=P_3= 2$ atm , $P_2=10$ atm and $T_1=300$ K.
- 2) Represent the cycle of transformations on a Clapeyron diagram P(V) .
- 3) Calculate the following energies (in joules) for each transformation: $Q, W, \Delta U, \Delta H$.

Exercise 5

1. Write down the combustion reaction of solid oxalic acid ($C_2H_2O_4$).
2. Calculate the standard enthalpy of this reaction, $\Delta_r H^\circ_{298k}$, at 298 K using the standard molar enthalpies of formation:

$\Delta H^\circ_f(C_2H_2O_4(s)) = -1822,2$ kJ/mol

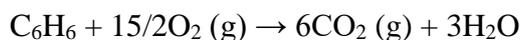
$\Delta H^\circ_f(CO_2(g)) = -393$ kJ/mol

$\Delta H^\circ_f(H_2O(l)) = -285,2$ kJ/mol

3. Deduce the standard variation in internal energy, $\Delta_r U^\circ_{298k}$.

Exercise 6

For the following reaction, at a temperature of 18°C and atmospheric pressure, we found a difference between the enthalpy and internal energy of the reaction ($\Delta H - \Delta U$) of -0.9 kcal.



Were the benzene and water taken in a gaseous or liquid state?

Exercise 7

One mole of ideal gas at an initial temperature of 298 K expands from a pressure of 5 atmospheres to a pressure of 1 atmosphere.

In each of the following cases :

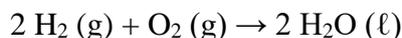
1. reversible isothermal expansion
2. irreversible isothermal expansion
3. reversible adiabatic expansion
4. irreversible adiabatic expansion

Calculate :

- a) the final temperature of the gas
 - b) the change in internal energy of the gas
 - c) the work done by the gas
 - d) the quantity of heat involved
 - e) the change in enthalpy of the gas
- we give : $C_v = 3/2 R$ and $C_p = 5/2 R$

Exercise 8

Calculate the enthalpy change of the reaction at 100 °C



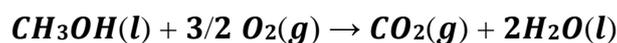
Substance	$\text{H}_2(\text{g})$	$\text{O}_2(\text{g})$	$\text{H}_2\text{O}(\ell)$
C_p (J/K mol)	$27,3 + 3,3 \cdot 10^{-3} T$	$29,9 + 4,2 \cdot 10^{-3} T$	75,2

Data: Standard enthalpy of formation of liquid water at 298 K :

$$\Delta H_f^\circ (\text{H}_2\text{O} (\ell)) = -286,0 \text{ kJ mol}^{-1}$$

Exercise 9

Total combustion of one mole of liquid methanol under standard conditions of pressure and temperature releases 725.2 kJ according to the following reaction:



1- Calculate the standard molar enthalpy of formation of liquid methanol.

The standard molar enthalpies of formation of $\text{H}_2\text{O}(\ell)$ and $\text{CO}_2(\text{g})$ are given.

$$\Delta H_f^\circ,_{298} (\text{H}_2\text{O}, \ell) = -285.2 \text{ KJ. mol}^{-1},$$

$$\Delta H_f^\circ,_{298} (\text{CO}_2, \text{g}) = -393.5 \text{ KJ. mol}^{-1}$$

2- Calculate the enthalpy of this reaction at 60°C.

The molar heats at constant pressure are given:

$$\begin{aligned}C_p(\text{H}_2\text{O}, l) &= 75.2 \text{ J. mol}^{-1} \cdot \text{K}^{-1}, \\C_p(\text{CH}_3\text{OH}, l) &= 81.6 \text{ J. mol}^{-1} \cdot \text{K}^{-1}, \\C_p(\text{O}_2, g) &= 34.7 \text{ J. mol}^{-1} \cdot \text{K}^{-1},\end{aligned}$$

$$\begin{aligned}C_p(\text{H}_2\text{O}, g) &= 38.2 \text{ J. mol}^{-1} \cdot \text{K}^{-1} \\C_p(\text{CH}_3\text{OH}, g) &= 53.5 \text{ J. mol}^{-1} \cdot \text{K}^{-1} \\C_p(\text{CO}_2, g) &= 36.4 \text{ J. mol}^{-1} \cdot \text{K}^{-1}\end{aligned}$$

Exercise 10 for student

One mole of an ideal gas in its initial state ($P_1=2 \text{ atm}$, $V_1=14 \text{ L}$) undergoes the following cycle of reversible transformations:

State 1 → State 2: isobaric heating which doubles its volume, $V_2 = 2V_1$.

State 2 → State 3: isothermal compression.

State 3 → State 1: isochoric cooling.

1. Determine the state parameters (P , V and T) of the three states (1, 2 and 3).
2. Calculate the work, heat and change in internal energy for each transformation.

Given:

$$C_v = 3R/2 \text{ and } R = 8.314 \text{ J. mol}^{-1} \cdot \text{K}^{-1} = 0.0821 \text{ L.atm. mol}^{-1} \cdot \text{K}^{-1}.$$