

### Tutorial Series N°2

#### Exercise 1

Calculate the work done when two moles of ideal gas **expand isothermally** at 298 K from  $P_1 = 10^6$  Pa at  $P_2 = 10^5$  Pa.

1. By reversible way.
2. Irreversible way

#### Exercise 2

A/ A sample composed of 2 mol of He undergoes isothermal expansion at 22°C from 22,8 L to 31,7 L

- (a) Reversibly
- (b) Against a constant external pressure equal to the final pressure
- (c) Freely against zero external pressure.

For the three processes calculate the work W.

B/ Calculate the work involved in an isothermal transformation of 32 g of gas O<sub>2</sub> from an initial pressure  $P_1 = 2$  atm to a final pressure  $P_2 = 10$  atm at a temperature  $T = 27^\circ\text{C}$ , in both cases: Reversible transformation and irreversible transformation.

#### Exercise 3

At constant pressure, 10g of ice is heated from  $-20^\circ\text{C}$  to  $120^\circ\text{C}$ .

1. What are the different steps?
2. For each stage, calculate the amount of heat? Deduce the total amount of heat?

We give :

$$c_{\text{ice}} = 0.5 \text{ cal.g}^{-1}.\text{K}^{-1}, c_{\text{liq water}} = 1 \text{ cal.g}^{-1}.\text{K}^{-1}, c_{p \text{ steam}} = 4.186 \text{ j/g.K}, L_m = 80 \text{ cal.g}^{-1}, L_v = 9700 \text{ cal.mol}^{-1}$$

#### Exercise 4

The reversible transformation of one mole of ideal gas from a state A to a final state B takes place along two paths:

Path (1) consisting of the transformations :

- A A': isobaric heating at  $10^5$  Pa from 298 K to 400 K.
- A' B: isothermal compression at 400 K from  $10^5$  Pa to  $10^6$  Pa.

Path (2) consisting of the transformations :

- A B': isothermal compression at 298 K from  $10^5$  Pa to  $10^6$  Pa.
- B' B: isobaric heating at  $10^6$  Pa from 298 K to 400 K.

1. For each path, determine the state parameters (P,V,T)?
2. Draw the Clapeyron diagram (P,V)?
3. Calculate the work W? What conclusions can you draw?

Given:  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$  ;  $C_p = 37.69 \text{ Jmol}^{-1}\text{K}^{-1}$

#### Exercise 5

A calorimeter contains a mass  $m_1 = 95$  g of water at  $T_1 = 20^\circ\text{C}$ . A mass  $m_2 = 100$  g of water is added at  $T_2 = 50^\circ\text{C}$ .

1. Calculate the final temperature  $t_f$ , neglecting the heat capacity of the calorimeter.
2. In reality the final temperature is  $T_f = 31.3^\circ\text{C}$  if the heat capacity of the calorimeter is not negligible. Calculate the water value  $\mu$  of the calorimeter.

We give:  $c_{\text{wate}} = 4185 \text{ J kg}^{-1}\text{K}^{-1}$

### Exercise 6

1. A calorimeter contains 100g of water at 25°C. Add 75g of water at 60°C. What would be the equilibrium temperature if the heat capacity of the calorimeter and its accessories could be neglected?
2. The equilibrium temperature observed is 37.5°C. Deduce the heat capacity of the calorimeter
3. The same calorimeter now contains 125 g of water at 13°C. A metal cylinder weighing 20 g at 97°C. The equilibrium temperature is 15.5°C.

Calculate the mass heat of the metal, assuming it is independent of T.

Data:  $c_{\text{liq water}} = 1 \text{ cal.g}^{-1}.\text{K}^{-1}$

### Exercise 7

We want to determine the specific heat of lead. A block of lead with a mass  $m_1=280\text{g}$  is taken out of an oven at a temperature  $T_1=98^\circ\text{C}$ . It is immersed in a calorimeter with a heat capacity of  $209 \text{ J.K}^{-1}$  containing a mass  $m_2=350\text{g}$  of water. The initial temperature is  $T_2 = 16^\circ\text{C}$ . The thermal equilibrium temperature  $T_e=17.7^\circ\text{C}$  is measured.

1. Express and calculate the energy received by the water during this transformation.
2. Similarly, calculate the energy received by the calorimeter.
3. Deduce the energy lost by the lead during this transformation.
4. Determine the mass heat of lead.

Data: Heat capacities by mass  $c$  ( $\text{J.kg}^{-1}.\text{K}^{-1}$ ): water: 4185; ice: 2100

Latent heat of fusion of ice:  $L_{\text{fusion(ice)}} = 333 \text{ kJ.kg}^{-1}$  at  $0^\circ\text{C}$ .

### Exercise 8

When 178 J of energy is supplied in the form of heat at constant pressure to 1.9 moles of gas, the temperature of the sample increases by 1.78 K.

Calculate the molar heat capacity at constant pressure ( $c_p$ ) for this gas.

### Exercise 9

A calorimeter contains 1000 g of water at 15°C. Add 1000 g of water at 65.5°C. The equilibrium temperature of the mixture is 40°C,

calculate the heat capacity and water content of the calorimeter.

$C_{\text{water}} = 4185 \text{ J Kg}^{-1} \text{ K}^{-1}$