University of KHANCHELA
Department of Science and Technology *THERMODYNAMICS*
*1^ST^* *2024-2025*

Final exam

Exercise1 (7points)

Calculate the change in enthalpy and internal energy of 10 g of ice whose temperature varies from -20 °C to 100 °C at atmospheric pressure.

The heats of mass of the pure bodies are given:

- Cp (H_2O, solid) = 0.5 cal. g^{-1} K^{-1} V (H_2O, solid) = 19.6 $cm^3.mol^{-1}$
- Cp (H_2O, liquid) = 1 cal. g^{-1} K^{-1} V (H_2O, liquid) = 18 $cm^3.mol^{-1}$

The enthalpies of mass of phase change:

- Δh° melting, at 273 K (H_2O, solid) = 80 $cal.g^{-1}$
- Δh° evaporation, 373 K (H_2O, liquid) = 539 $cal.g^{-1}$

Exercise2 (7points)

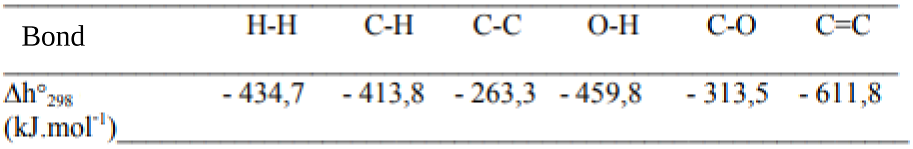
Calculate the standard enthalpy of the following reaction:

$$C_2H_4\,(g) + H_2O\,(g) \rightarrow C_2H_5OH\,(g)$$

1. From the standard molar enthalpies of formation.
2. From the binding energies.
3. Give an explanation for the results found.

We give: $\Delta H_f°{}_{,298}$ (C_2H_4,g) = 33.6 kJ.mol-1 $\Delta H_f°{}_{,298}$ (C_2H_5OH,g) = -275.9 kJ.mol-1

$\Delta H_f°{}_{,298}$ (H_2O,g) = -242.4 kJ.mol-1



Bond	H-H	C-H	C-C	O-H	C-O	C=C
$\Delta h°_{298}$ ($kJ.mol^{-1}$)	- 434,7	- 413,8	- 263,3	- 459,8	- 313,5	- 611,8

Exercise3 (6points)

1-Give the work formula for

- isothermal transformation (T = cst)
- isobaric trasformation (p=cst)
- Reversible adiabatic transformation (dQ= 0)

University of KHANCHELA
Department of Science and Technology *THERMODYNAMICS*
1ST *2024-2025*

الامتحان النهائي

التمرين 1(7 نقاط)

احسب التغيُّر في الإنثالبي والطاقة الداخلية لـ 10 جرام من الثلج الذي تتراوح درجة حرارته من -20 درجة مئوية إلى 100 درجة مئوية عند الضغط الجوي.

حرارة كتلة الأجسام النقية مُعطاة:

- Cp (H_2O, solid) = 0.5 cal. g^{-1} K^{-1} V (H_2O, solid) = 19.6 $cm^3.mol^{-1}$
- Cp (H_2O, liquid) = 1 cal. g^{-1} K^{-1} V (H_2O, liquid) = 18 $cm^3.mol^{-1}$

- إنثالبي كتلة التغير في الطور:

- $\Delta h°$ melting, at 273 K (H_2O, solid) = 80 $cal.g^{-1}$
- $\Delta h°$ evaporation, 373 K (H_2O, liquid) = 539 $cal.g^{-1}$

تمرين2 (7 نقاط)

احسب الإنثالبي القياسي للتفاعل التالي:

$$C2H4\ (g) + H2O\ (g) \rightarrow C2H5OH\ (g)$$

1. من الإنثالبي المولي القياسي للتكوين.
2. من طاقات الربط.
3. إعطاء تفسير للنتائج التي تم التوصل إليها.

نُعطي: $\Delta H_f°_{,298}$ (C_2H_5OH,g) = -275.9 kJ.mol-1 $\Delta H_f°_{298}$ (C_2H_4,g) = 33.6 kJ.mol-1

$\Delta H_f°_{298}$ (H_2O,g) = -242.4 kJ.mol-1

الرابطة	H-H	C-H	C-C	O-H	C-O	C=C
$\Delta h°_{298}$ (kJ.mol^{-1})	- 434,7	- 413,8	- 263,3	- 459,8	- 313,5	- 611,8

التمرين3 (6 نقاط)

-أوجد معادلة العمل لـ

-التحول المتساوي الحرارة (T = cst)

-التحول المتساوي الضغط الحراري(p=cst)

- التحوُّل الأديباتيكي الانعكاسي (dQ= 0)

University of KHANCHELA
Department of Science and Technology *THERMODYNAMICS*
1^{ST} *2024-2025*

Final exam correction

Exercise1 (7points)

$$\underset{253K}{(H_2O,s)} \xrightarrow{\Delta H_1^\circ,\Delta U_1^\circ} \underset{273K}{(H_2O,s)} \xrightarrow{\Delta H_2^\circ,\Delta U_2^\circ} \underset{273K}{(H_2O,l)} \xrightarrow{\Delta H_3^\circ,\Delta U_3^\circ} \underset{373K}{(H_2O,l)} \xrightarrow{\Delta H_4^\circ,\Delta U_4^\circ} \underset{373K}{(H_20,g)} \quad \boxed{1.0}$$

1. The enthalpy of heating of the ice is:

$$\Delta H_1^\circ = \int_{253}^{273} mC_p(H_20,s)dT \quad \boxed{0.5}$$

Note that the specific heats at constant pressure are mass.

$\Delta H_1°$ = 10*0.5*(273-253) = 100cal. $\boxed{0.5}$

2. The enthalpy of fusion of ice is: ΔH° = m ΔH° fusion $\boxed{0.5}$

$\Delta H_2°$ = 10*80 = 800cal $\boxed{0.5}$

3. The enthalpy of heating of liquid water is:

$$\Delta H_3^\circ = \int_{273}^{373} mC_p(H_20,l)dT \quad \boxed{0.5}$$

$\Delta H_3°$ = 10.1. (373-273) = 1000cal. $\boxed{0.5}$

4. The enthalpy of vaporisation of water is: ΔH4° = m $\Delta H°_{vap}$ $\boxed{0.5}$

ΔH4° = 10.539 = 5390cal $\boxed{0.5}$

The change in enthalpy of transformation of water is : $\Delta H° = \sum \Delta H°_i = 7290$ cal. $\boxed{0.25}$

a) ΔH° = ΔU° + Δ (PV) => ΔU° = ΔH° - Δ (PV) $\boxed{0.5}$

Δ (PV) = P ΔV = 0 : $V(s)_{273} - V(s)_{253} = 0$ **=>**$\Delta H°_1 = \Delta U°_1$ = 100 cal. $\boxed{0.25}$

b) $\Delta U°_2 = \Delta H°_2 - P\,[V(l)_{273} - V(s)_{273}]$ $\boxed{0.25}$

$V(l)_{273} - V(s)_{273} = (18 - 19{,}6) = -1{,}6\ cm^3.mol^{-1} = -1{,}6.10^{-6}\ m^3.mol^{-1}$ $\boxed{0.25}$

$\Delta U°_2 = 800 - [1{,}013\ .10^5\ (-1{,}6\ .\ 10^{-6})]\ /4{,}18.\ 18 = 800 - 2{,}15.10^{-3} \approx \Delta H°_2$

$\Delta U°_2 \approx 800$ cal. $\boxed{0.25}$

c) $\Delta U°_3 = \Delta H°_3 = 1000$ cal. $\boxed{0.25}$

Exercise2 (7points)

$$C_2H_4\,(g) + H_2O\,(g) \quad \rightarrow \quad C_2H_5OH\,(g) \qquad \Delta H_r{}^\circ{}_{298\,K}$$

1. According to **Hess's law**, the standard enthalpy of the reaction is :

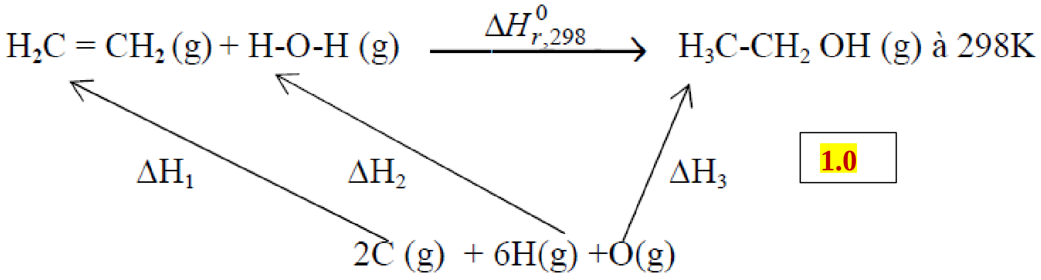
$$\Delta H^0_{R(298)} = \sum \Delta H^0_f(\text{PRODUCTS}) - \sum \Delta H^0_f(\text{REAGENTS})$$ 1.0

$$\Delta H_r{}^\circ{}_{,298} = \Delta h_f{}^\circ{}_{,298}\,(C_2H_5OH,g) - \Delta h_f{}^\circ{}_{,298}\,(C_2H_{4,}\,g) - \Delta h_f{}^\circ{}_{,298}\,(H_20,\,g)$$ 0.50

$$\Delta H_r{}^\circ{}_{,298} = -234{,}1 - (33{,}6) - (-242{,}4) = -25{,}3\ kJ$$ 0.25

2. All substances are in a gaseous state. Therefore, to calculate the enthalpy of reaction, we can apply **Hess's law** according to the binding energies or the cycle method.

$\Delta H^\circ_{r,298} = \Sigma n_i \Delta h^\circ_{298}$ Product's bond $-\Sigma n_j \Delta h^\circ_{298'}$ Reactive's bond 1.0



1.0

$$\Delta H^\circ_{r,298} = \Delta H^\circ_3 - \Delta H^\circ_1 - \Delta H^\circ_2$$ 0.5

$$\Delta H^\circ_1 = 4\Delta h^\circ_{298}(C-H) + \Delta h^\circ_{298}(C=C)$$ 0.50

$$\Delta H^\circ_1 = [4(-413{,}8) - 611{,}8] = -2267\ kJ$$ 0.25

$$\Delta H^\circ_2 = 2\Delta h^\circ_{298}(O-H)$$ 0.50

$$\Delta H^\circ_2 = 2(-459{,}8) = -919{,}6\ kJ$$ 0.25

$$\Delta H^\circ_3 = 5\Delta h^\circ_{298}(C-H) + \Delta h^\circ_{298}(C-O) + \Delta h^\circ_{298}(C-C) + \Delta h^\circ_{298}(O-H)$$ 0.50

$$\Delta H^\circ_3 = -3105{,}6kJ$$ 0.25

$$\Delta H^\circ_{r,298} = \Delta H^\circ_3 - \Delta H^\circ_1 - \Delta H^\circ_2 = 79kJ$$ 0.25

c) The value found in (b) is different from that found in (a) because the enthalpies of the bond energies are calculated using approximate methods. It is assumed that the bonds are identical and have the same value in the different molecules.

0.25

Exercise3 (6points)

- **isothermal transformation (T = cst)**

1.0

$$\boxed{W_{12} = n\ R\ T\ ln\frac{P_2}{P_1}} \Rightarrow \boxed{W_{12} = n\ R\ T\ ln\frac{V_1}{V_2}}$$

1.0

- **isobaric trasformation (p=cst)**

1.0

$$\boxed{W_{12} = -P_1\ (V_2 - V_1)} \qquad \boxed{W_{12} = -n\ R\ (T_2 - T_1)}$$

1.0

- **Reversible adiabatic transformation (dQ= 0)**

$$\boxed{W_{12} = \frac{n\ R\ T_2 - n\ R\ T_1}{(\gamma - 1)} = \frac{P_2\,V_2 - P_1\,V_1}{(\gamma - 1)}}$$

2.0