Thermodynamics exam answers

1st year SM, ST

exercise 1 5 points

1) Heat Capacity of the Calorimeter :

- Cold water : $Q_1 = m_1 C_{water}(\theta_e - \theta_1)$
- Hot water : $Q_2 = m_2 C_{water}(\theta_e - \theta_2)$
- Calorimeter : $Q_{cal} = C_{cal}(\theta_e - \theta_1)$

A

(*) The system {water$_1$ + Water$_2$ + Calorimeter} is isolated :

$\sum Q_i = 0 \Rightarrow Q_1 + Q_{cal} + Q_2 = 0$ —— 0,25

$m_1 C_{water}(\theta_e - \theta_1) + C_{cal}(\theta_e - \theta_1) + m_2 C_{water}(\theta_e - \theta_2) = 0$ 0,25

$$C_{cal} = \frac{m_1(\theta_e - \theta_1) + C_{water}(\theta_e - \theta_2)}{\theta_1 - \theta_2} = \frac{0,1 \times 4185(35,9-18) + 0,08 \times 4185(35,9-60)}{18-35,9}$$

$\boxed{C_{cal} = 32,26 J.K^{-1}}$ —— 1

B

(*) The calorimeter capacity is negligible :

→ Cold water : $Q_1 = m_1 C_{water}(\theta_e - \theta_1)$ —— 0,25

– Hot water : $Q_2 = m_2 C_{water}(\theta_e - \theta_2)$ —— 0,25

$\sum Q_i = 0 \Rightarrow Q_1 + Q_2 = 0$ —— 0,25

$m_1 C_{water}(\theta_e - \theta_1) + m_2(\theta_e - \theta_2) = 0 \Rightarrow \theta_e = \frac{m_1\theta_1 + m_2\theta_2}{m_1 + m_2}$ 0,5

$\theta'_e = 36,66°C = \frac{0,1 \times 18 + 0,08 \times 60}{0,1 + 0,08} = 36,66°C$ 0,25

$\boxed{\Rightarrow \theta'_e \simeq \theta_e}$ $\boxed{1}$

Scanné avec CamScanner

2) 10g of ice at $-2°C$ is added to the system

* Heat ice from $-2°C$ to $0°C$

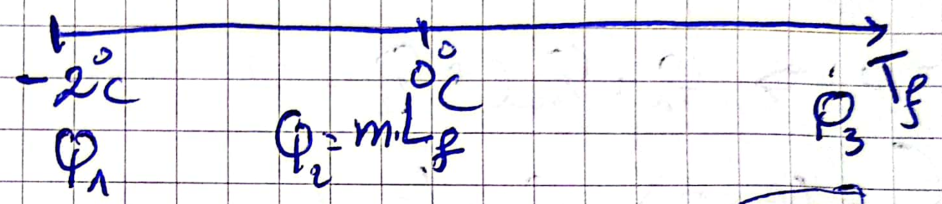
$$\varphi_1 = m C_{ice} \Delta T = 0,01 \times 2100 \times 2 = 42 J$$

* Melt the ice at $0°C$

$$\varphi_2 = m_{ice} L_f = 0,01 \times 334000 = 3340 J$$

* Heat water to final temp T_f

$$\varphi_3 = 0,01 \times 4185 (T_f - 0)$$



$$\varphi_{gain} = \varphi_{loss} \quad \text{or} \quad \Sigma \varphi_i = 0$$ 0,25

0,5

$$\Rightarrow \varphi_{ice} = \varphi_1 + \varphi_2 + \varphi_3 = 42 + 3340 + 41,85 \cdot \theta_f$$

$$\varphi_{water} = m_{water} \cdot C_{water} \cdot (\theta_f - 35,9) = 0,18 \cdot 4185 (\theta_f - 35,9)$$

$$\varphi_{water} = 753,3 (\theta_f - 35,9)$$

Since the system is isolated, then sum of all heat exchanges must be zero:

0,5

$$\varphi_{ice} + \varphi_{water} = 0$$

$$(42 + 3340 + 41,85 \cdot \theta_f) + 753,3 \cdot (\theta_f - 35,9) = 0$$

0,5 $(41,85 + 753,3)\theta_f = 27064,47 - 3382$

$$795,15 \, \theta_f = 23682,47 \Rightarrow \theta_f = \frac{23682,47}{795,15}$$

$\Rightarrow \theta_f = 29,78°C$

Scanné avec CamScanner

Exercise 3 (7 point)

1) The standard Entalpy change of reaction ΔH°_R at 298K

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

$$\Delta_r H^\circ_{298} = \sum \Delta H_f^\circ (\text{products}) - \sum \Delta H_f^\circ (\text{Reactants}) \quad 0{,}25$$

$$\Delta_r H^\circ = [3\Delta H_f^\circ CO_2 + 4\Delta H_f^\circ H_2O] - [\underset{\Delta H_f C_3H_8}{-104} + 5\underset{\Delta H_f O_2}{(0)}] \quad 0{,}25$$

$$\Delta H_R^\circ = [3(-393) + 4(-285)] - [-104 + 0] \quad 0{,}25$$

$$\Delta H_R^\circ = -1179 - 1140 + 104 = -2319 + 104$$

$$\boxed{\Delta H_R = -2215 \text{ Kj/mol}} \quad 0{,}5$$

2) Heat of the Reaction at constant volume ΔU_r°

$$\Delta U_r^\circ = \Delta H_r^\circ - \Delta n_g \cdot RT \quad 0{,}5$$

$T = 298K$ / Moles of gases : $\Delta n_g = 3 - 6 = -3$ $\quad 0{,}25$

$$\Delta U_R^\circ = -2215 - (-3)(0{,}008314)(298) = -2215 + 7{,}43$$

$$\Delta U_R^\circ = \boxed{-2207{,}6 \text{ Kj/mol}} \quad 0{,}5$$

3) Entalpy change at 348K

$$\Delta H^\circ_{348} = \Delta H^\circ_{298} + \Delta C_p \cdot \Delta T \quad 0{,}25$$

$\Delta C_p = 45 J$

$\Delta T = 348 - 298 = 50K$

$$\Delta H^{\circ}_{348} = -2215 + 0{,}045 \times 50 = -2215 + 2{,}25$$

$$= \boxed{-2212{,}75 \ \text{KJ/mol}} \quad 0{,}5$$

4) The bond energy in propane $C_3H_8(g)$

Hess Law via entalpy cycle :

$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$$

0,5

$$3C(s) + 4H_2(g) \xrightarrow{\Delta H^{\circ}_{f(C_3H_8 g)}} C_3H_8(g)$$

0,5 $\quad 3\Delta H_{sub}(C) \downarrow \qquad$ 0,5 $\quad 4\Delta H_{dis}(H_2) \downarrow \qquad (+)$

$$3C(g) + 8H(g) \xrightarrow{2\Delta H_{bond}(C-C) + 8\Delta H_{bond}^{CH}} C_3H_8(g)$$

0,25 $\quad$ 0,25

0,5

$$\Delta H^{\circ}_{f(C_3H_8)} - \boxed{2\Delta H_{bond}(C-C)}^{?} - 8\Delta H_{bond}(C-H) - 4\Delta H_{dis}(H_2) - 3\Delta H_{sub}(C) = 0$$

$$\Delta H^{\circ}_{f(C_3H_8)} - 8\Delta H_{C-H\,(bond)(f)} + 4\Delta H_{f}(\cancel{H_2}) - 3\Delta H_{sub} = 2\Delta H_{bond}(C-C) \quad 0{,}25$$

$$-104 - 8(-415) + 4(-435) - 3(720) = 2\Delta H_{bond}(C-C)$$

$$\Rightarrow -684 = 2\Delta H_{bond}(C-C) \Rightarrow \quad 0{,}25$$

$$\Delta H_{C-C} = \frac{-684}{2} = -342 \ \text{Kj/mol}$$

$$\Delta H_{C-C} = -342 \ \text{Kj/mol} \quad 0{,}5$$

End

Scanné avec CamScanner