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Series N°3

Exercise 1 :

Let the following reaction be carried out on 1 mole of zinc oxide ZnO at 25°C and under 1 atm:

$$\mathbf{C\ (s) + ZnO\ (s) \rightarrow Zn\ (s) + CO\ (g)}$$

Considering that carbon monoxide CO behaves like an ideal gas, calculate:

1) The amount of heat Q at constant pressure.
2) The amount of heat Q at constant volume.

Data : At 25°C : $\Delta H°_f$ (CO) = - 110,3 KJ/mol; $\Delta H°_f$ (ZnO) = - 347,8 KJ/mol

Exercise 2 :

We provide the following combustion reactions under standard conditions:

$\mathbf{C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2H_2O\ (l)}$ $\Delta H°_{R,298}$ (1) = -332 kcal/mol
$\mathbf{H_2\ (g) + ½\ O_2\ (g) \rightarrow H_2O\ (l)}$ $\Delta H°_{R,298}$ (2) = -68.3 kcal/mol
$\mathbf{C_2H_6\ (g) + 7/2\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3H_2O\ (l)}$ $\Delta H°_{R,298}$ (3) = -72,8 kcal/mol

1) Determine the standard enthalpy $\Delta H°_{R,\ 298}$ (4) of the following reaction:

$\mathbf{C_2H_4\ (g) + H_2\ (g) \rightarrow C_2H_6\ (g)}$

2) Calculate the enthalpy of formation of C_2H_6 (g).
3) Determine the enthalpy of formation of the C-C bond in C_2H_6 (g).

Data : $\Delta H°_{f,298}$ (C_2H_4, g) = 8,04 kcal/mol ; $\Delta H°_{sublimation}$(C,s) = 171,2 kcal/mol
$\Delta H°_{f,298}$ (H-H) = -104 kcal/mol ; $\Delta H°_{f,298}$ (C-H) = -99,5 kcal/mol

Exercise 3 :

Calculate the standard enthalpy of the following reaction:

$\mathbf{C_2H_4\ (g) + H_2O\ (g) \rightarrow C_2H_5OH\ (g)}$

1) from the standard molar enthalpies of formation.
2) from bond energies.
3) provide an explication for the found results.

Data :

$\Delta H°_{f,298}$(C_2H_4,g) = 33,6 Kj/mol ; $\Delta H°_{f,298}$(C_2H_5OH,g) = -275,9Kj/mol
$\Delta H°_{f,298}$ (H_2O,g) = -242,4 Kj/mol ; R = 8,314 J/mol.K.

bond	H-H	C-H	C-C	O-H	C-O	C=C
$\Delta H°_{f,298(bond)}$ (KJ/mol)	- 434,7	- 413,8	- 263,3	- 459,8	- 313,5	- 611,8

Exercise 4 :

The decomposition of oxalic acid $C_2H_2O_4$ occurs according to the following reaction:

$\mathbf{C_2H_2O_4\ (s) \rightarrow CO_2\ (g) + H_2CO_2\ (l)}$

1) Calculate the standard enthalpy of formation of $C_2H_2O_4$(s) at T = 298 K.
2) Calculate the standard enthalpy of this reaction of $C_2H_2O_4$(s) at T=298K.
3) Calculate the internal energy change of this reaction at T_1 = 298 K and then at T_2 = 400 K.

Data :

bond	H-H	O=O	C-C	C-O	C=O	O-H
$\Delta H°_{f,\ 298(bond)}$ (KJ/mol)	-434,7	-494,9	-345,3	-357,4	-727,6	-462,3

Compound	$C_2H_2O_4$ (s)	H_2CO_2 (l)	H_2CO_2 (g)	CO_2 (g)
c_p(J/mol.K)	105,9	99,0	45,7	37,2

$\Delta H°_{sub}$ (C) = 718,4 KJ/mol ; $\Delta H°_{sub}$ ($C_2H_2O_4$) = 248,2 KJ/mol

$\Delta H°_f$ (H_2CO_2) = - 409 KJ/mol ; $\Delta H°_f$ (CO_2) = - 397,3 KJ/mol

$\Delta H°_{vap}$ (H_2CO_2) = 22,7 KJ/mol ; T_{vap}(H_2CO_2) = 374 K

Exercise 5 :

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

CH_3OH (l) + 3/2 O_2 (g) $\rightarrow$ CO_2 (g) + 2H_2O (l).

1) Calculate the standard enthalpy of formation of liquid methanol.

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

3) Calculate the enthalpy of this reaction at 127°C and at one atmosphere pressure, knowing that at this pressure, methanol boils at 64,5°C and water at 100°C.

Data :

$\Delta H°_{f,298}$ (H_2O, l) = -285,2 Kj/mol ; $\Delta H°_{f,298}$ (CO_2, g) = -393,5 Kj/mol

$\Delta H°_{vap,\ 373}$ (H_2O, l) = 44 Kj/mol ; $\Delta H°_{vap,\ 337,5}$ (CH_3OH, l) = 35,4 KJ/mol

Compound	H_2O (l)	H_2O (g)	CH_3OH (l)	CH_3OH (g)	O_2 (g)	CO_2 (g)
c_p(J/mol.K)	75,2	38,2	81,6	53,5	34,7	36,4