Answer on Question # 59761 – Chemistry – General Chemistry

Use the mean bond enthalpies given below (in kj/mol) to calculate the enthalpy change of each reaction.

$N_2(g) + 3H_2(g) \Rightarrow 2NH_3(g)$

$H_2(g) + I_2(g) \Rightarrow 2HI(g)$

$H_2(g) + \frac{1}{2}O_2(g) \Rightarrow H_2O(g)$

$N \equiv N$: 944, H-H: 436, N-H: 388, I-I: 151, H-I: 299, O-H: 463 and O=O: 496.

Solution:

1) $N_2(g) + 3H_2(g) \Rightarrow 2NH_3(g)$

The bonds of a nitrogen molecule:

$:N:::N:$ or $:N \equiv N:$

The bonds of a hydrogen molecule:

$H:H$ or $H-H$

The bonds of an ammonia molecule:

$$\begin{matrix} & H & \\ & : & \\ : & N & :H \\ & : & \\ & H & \end{matrix} \quad \text{or} \quad \begin{matrix} & H & \\ & | & \\ : & N & -H \\ & | & \\ & H & \end{matrix}$$

The enthalpy change of this reaction (enthalpy is indicated with letter H):

$$\Delta H_{NH_3} = 2H_{NH_3} - H_{N_2} - 3H_{H_2} = 2 \cdot 3H_{N-H} - H_{N \equiv N} - 3 \cdot H_{H-H} = 6 \cdot 388 - 944 - 3 \cdot 436 = 76[kJ].$$

2) $H_2(g) + I_2(g) \Rightarrow 2HI(g)$

The bonds of an iodine molecule:

$:\ddot{\underset{..}{I}}:\ddot{\underset{..}{I}}:$ or $:\ddot{\underset{..}{I}}-\ddot{\underset{..}{I}}:$

The bonds of a hydroiodic acid molecule:

$H:\ddot{\underset{..}{I}}:$ or $H-\ddot{\underset{..}{I}}:$

The enthalpy change of this reaction:

$$\Delta H_{HI} = 2H_{HI} - H_{H_2} - H_{I_2} = 2 \cdot H_{H-I} - H_{H-H} - H_{I-I} = 2 \cdot 299 - 436 - 151 = 11[kJ].$$

3) $H_2(g) + \frac{1}{2}O_2(g) \Rightarrow H_2O(g)$

The bonds of an oxygen molecule:

$\ddot{\underset{..}{O}}::\ddot{\underset{..}{O}}$ or $\ddot{\underset{..}{O}}=\ddot{\underset{..}{O}}$

The bonds of a water molecule:

$H:\ddot{\underset{..}{O}}:H$ or $H-\ddot{\underset{..}{O}}-H$

The enthalpy change of this reaction:

$$\Delta H_{H_2O} = H_{H_2O} - H_{H_2} - \frac{1}{2}H_{O_2} = 2 \cdot H_{O-H} - H_{H-H} - \frac{1}{2}H_{O=O} = 2 \cdot 463 - 436 - \frac{1}{2} \cdot 496 = 242\left[kJ\right].$$

Answer: $\Delta H_{NH_3} = 76\left[kJ\right]$; $\Delta H_{HI} = 11\left[kJ\right]$; $\Delta H_{H_2O} = 242\left[kJ\right]$.