Thermochemistry

P15. For maleic acid ($C_4H_4O_4$), the heat of combustion at constant volume and 25 °C is –1363 kJ mol^{-1}. Calculate the heat of combustion at constant pressure. *[$\Delta_{comb}H$ = –1360.5 kJ mol^{-1}]*

P16. In a bomb calorimeter with a heat capacity of C = 641 J K^{-1}, 0.3212 g glucose ($C_6H_{12}O_6$, M = 180.16 g mol^{-1}) is burned. During the process, the temperature of the calorimeter increases with 7.793 K. Calculate the $\Delta_{comb}U^{\ominus}(T^{\ominus})$ standard internal energy change and $\Delta_{comb}H^{\ominus}(T^{\ominus})$ standard enthalpy change for the combustion of glucose. *[$\Delta_{comb}U^{\ominus}(T^{\ominus}) = \Delta_{comb}H^{\ominus}(T^{\ominus})$ = –2801 kJ mol^{-1}]*

P17. 11.5 g of nitrobenzene is burned in a calorimeter bomb. At 25 °C, –290 kJ heat is measured in the calorimeter bomb. Calculate the standard heat of formation for nitrobenzene when the standard heat of formation values for carbon dioxide and water are –393.5 kJ mol^{-1} and –285.8 kJ mol^{-1}, respectively. (Under these reaction conditions, the nitrogen content of nitrobenzene is not oxidized, it forms nitrogen gas during combustion.) *[$\Delta_{form}H^{\ominus}$(nitrobenzene) = 28.64 kJ mol^{-1}]*

P18. Calculate the standard reaction enthalpy for the hydrogenation of benzene at 25 °C using the following standard combustion enthalpy values: benzene: –3268 kJ mol^{-1}; cyclohexane: –3902 kJ mol^{-1}; hydrogen: –285.8 kJ mol^{-1}. *[$\Delta_rH^{\ominus}$ = –223 kJ mol^{-1}]*

P19. Calculate the enthalpy of formation for formaldehyde (HCHO) at 330 K. The standard enthalpy of formation at 298 K is –119 kJ mol^{-1}. $C_{p,m}$ molar heat capacities of the reactants and products at constant pressure are as follows: formaldehyde: 19.3 J mol^{-1} K^{-1}; hydrogen: 28.9 J mol^{-1} K^{-1}; graphite: 4.2 J mol^{-1} K^{-1}; oxygen: 26.4 J mol^{-1} K^{-1}. *[$\Delta_{form}H$(330 K) = –120 kJ mol^{-1}]*

P20. Calculate the standard lattice enthalpy of $CaBr_2$, using the following thermodynamic data:

$\Delta_{form}H^{\ominus}(CaBr_2)$ = –682.8 kJ mol^{-1},

$\Delta_{sub}H^{\ominus}(Ca)$ = 178.2 kJ mol^{-1},

$\Delta_iH^{\ominus}(Ca \rightarrow Ca^+)$ = 589.7 kJ mol^{-1},

$\Delta_iH^{\ominus}(Ca^+ \rightarrow Ca^{2+})$ = 1145.0 kJ mol^{-1},

$\Delta_{diss}H^{\ominus}(Br_2)$ = 193.0 kJ mol^{-1},

$\Delta_{ea}H^{\ominus}(Br^-)$ = –324.5 kJ mol^{-1},

$\Delta_{vap}H^{\ominus}(Br_2)$ = 15.5 kJ mol^{-1}. *[$\Delta_{lat}H^{\ominus}(CaBr_2)$ = 2155.2 kJ mol^{-1}]*