Hess Law Of Constant Heat Summation Chemistry Questions with Solutions

Q-1: Which of the following are Hess's Law applications?
a) Enthalpy of Formation Calculations
b) Enthalpy Change Prediction
c) Enthalpy of Allotropic Transformation Calculations
d) All of the above

Answer: d) All of the above

Q-2: Calculate the enthalpy of formation of carbon monoxide (CO) from the following data:
i) $C(s)+O_2(g) \rightarrow CO_2(g)$; $\Delta H = -393.3$ kJ/mol
ii) $CO + \frac{1}{2} O_2(g) \rightarrow CO_2(g)$; $\Delta H = -282.8$ kJ/mol

Answer: We aim at
$C(s) + \frac{1}{2} O_2(g) \rightarrow CO(g)$; $\Delta H = ?$

Subtracting equation ii) from i), we get
$C(s) + \frac{1}{2} O_2(g) \rightarrow CO(g)$

Therefore, $\Delta H = -393.3 - (-282.8)$ kJ/mol = -110.5 kJ/mol

Q-3: The thermite reaction used for welding of metals involves the reaction
$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$
What is ΔH^o at 25°C for this reaction? Given that the standard heats of formation of Al_2O_3 and Fe_2O_3 are -1675.7 kJ and -828.4 kJ/mol respectively.

Answer: We are given
i) $2Al(s) + 3/2\ O_2(g) \rightarrow Al_2O_3(s)$; $\Delta H = -1675.7$ kJ/mol
ii) $2Fe(s) + 3/2\ O_2(g) \rightarrow Fe_2O_3(s)$; $\Delta H = -828.4$ kJ/mol

We aim at
$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$; $\Delta H = ?$

Equation (i) - Equation (ii) gives
$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$

$\Delta H = -1675.7 - (-828.4)$ kJ/mol = -847.3 kJ/mol

Q-4: $CH_4 + ½O_2 \rightarrow CH_3OH$ has a negative enthalpy. Which of the following relationships is correct if the enthalpy of combustion of CH_4 and CH_3OH is z and y, respectively?
a) z>y
b) z<y
c) z=y
d) Information insufficient

Answer: b) z<y
Explanation:
i) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$; $\Delta H=z$
ii) $CH_3OH + 3/2O_2 \rightarrow CO_2 + 2H_2O$; $\Delta H= y$
(i)-(ii) gives the required equation, that is, $CH_4 + ½O_2 \rightarrow CH_3OH$
Thus, for the given reaction, $\Delta H = z-y = -ve$
This implies, z<y.

Q-5: Hess' Law states that the total amount of heat evolved or absorbed is independent of
a) The nature of the initial reactants,
b) The nature of the final products.
c) The path taken,
d) All of the above

Answer: c) Hess' Law states that the total amount of heat evolved or absorbed is independent of the path taken.

Q-6: How are thermochemical equations advantageous in Hess law?
Answer: Because thermochemical equations can be treated as algebraic equations that can be added, subtracted, multiplied, or divided. As a result, they are advantageous in Hes's' law.

Q-7: If for (i) $C + O_2 \rightarrow CO_2$
(ii) $C + ½ O_2 \rightarrow CO$
(iii) $CO + ½ O_2 \rightarrow CO_2$ the heats of reaction are Q,-12 and -4 respectively. Then Q = _____.
a) -2
b) 2
c) -22
d) -16

Answer: d) -16
Explanation: Adding equation ii) and iii) gives the required equation i) for which we have to calculate Q.
Thus, Q= -12-4 = -16.

Q-8: Calculate the change in enthalpy for the reaction $2H_2O_2 \rightarrow 2H_2O + O_2$, if heat of formation for H_2O_2 and H_2O are -190 kJ/mol and -286 kJ/mol respectively.
Answer: $\Delta H^o_{(reaction)} = [\ 2\Delta H^o_f(H_2O) + \Delta H^o_f(O_2)] - [2\Delta H^o_f(H_2O_2)] = [2(-286) + (0)] - [2(-190)] = -192$ kJ.

Q-9: The standard enthalpy of combustion at 25°C of hydrogen, cyclohexene and cyclohexane are -241, -3800 and -3920 kJ/mol respectively. Calculate the heat of hydrogenation for cyclohexene.

Answer:
i) $H_2 + ½\ O_2 \rightarrow H_2O$; $\Delta H = -241$kJ
ii) $C_6H_{10} + 17/2\ O_2 \rightarrow 6CO_2 + 5H_2O$; $\Delta H = -3800$ kJ
iii) $C_6H_{12} + 9O_2 \rightarrow 6CO_2 + 6H_2O$; $\Delta H = -3920$ kJ
We aim at $C_6H_{10} + H_2 \rightarrow C_6H_{12}$; ΔH=?
Equation (i) + Equation (ii) - Equation (iii) gives the required result.
Thus, $\Delta H = -241+(-3800)-(-3920) = -121$ kJ

Q-10: The heat of formation of
i) $CO_2(g)$ from its elements is +94.4 kcal
ii) CuO(s) from its elements is 151.8 kcal and
iii) The heat of reaction between CuO(s) and $CO_2(g)$ is +42.25 kcal.Calculate the heat of formation of $CuCO_3(s)$.

Answer: We are given
i) $C(s) + O_2(g) \rightarrow CO_2(g)$; $\Delta H = 94.4$ kcal
ii) $Cu(s) + ½\ O_2\ (g) \rightarrow CuO(s)$; $\Delta H = 151.8$ kcal
iii) $CuO(s) + CO_2(g) \rightarrow CuCO_3(s)$; $\Delta H = 42.25$ kcal
We aim at
$Cu(s) + C(s) + 3/2\ O_2 \rightarrow CuCO_3(s)$; ΔH= ?
Eqn(i) + Eqn(ii) + Eqn(iii) gives the required result.
$\Delta H = 94.4 + 151.8 + 42.25 = 288.45$ kcal.
Q-11: What is the name of the law that states that the total enthalpy change in a chemical reaction remains constant at the same temperature?
Answer: Hess's Law of constant heat summation.

Q-12: What do you mean by a thermochemical equation? Can we use fractional coefficients in such an equation?
Answer: A thermochemical equation is one in which a balanced chemical equation not only indicates the quantities of the different reactants and products but also the amount of heat evolved or absorbed. Yes, a thermochemical equation can be written using fractional coefficients.

Q-13: ΔH^o_f of $CO_2(g)$, CO(g), $N_2O(g)$ and $NO_2(g)$ in kJ/mol are respectively -393, -110,-81 and -34. Calculate ΔH in kJ for the following reaction.

$2NO_2(g) + 3CO(g) \rightarrow N_2O(g) + 3CO_2(g)$

Answer: $\Delta H^o_{(reaction)} = [\Delta H^o_f(N_2O) + 3\Delta H^o_f(CO_2)] - [3(\Delta H^o_f(CO) + 2(\Delta H^o_f(NO_2)]$
On substituting values, we get
$\Delta H^o_{(reaction)} == [-81 + 3(-393)] - [3(-110) + 2(-34)] = -836$ kJ

Q-14: What is the basis of Hess's Law?
Answer: Hess' law is based on the fact that enthalpy is a state function, which means that enthalpy change depends only on the initial and final states and not on the path taken.

Q-15: What is the significance of bond enthalpy?
Answer: One important significance of a bond enthalpy is in calculating the enthalpy of atom formation.

Practice Questions on Hess Law Of Constant Heat Summation

Q-1: Hess's Law is concerned with the
a) Entropy of the System
b) Heat change of the Reaction
c) Kinetic Rate of Reaction
d) Thermodynamics of the Reaction

Answer: b) Hess's Law is concerned with the heat changes for the reactions.

Q-2: There are two crystalline forms of PbO: one yellow and one red. These two forms have standard enthalpies of formation of -217.3 and -219.0 kJ per mol, respectively. Determine the enthalpy change during the solid-solid phase transition.
PbO (yellow) → PbO (red)

Answer:
i) $Pb(s) + ½\ O_2(g) \rightarrow$ PbO (yellow) ; $\Delta H = -217.3$ kJ/mol
ii) $Pb(s) + ½\ O_2(g) \rightarrow$ PbO (red) ; $\Delta H = -219.0$ kJ/mol

On reversing equation i) and adding it to equation ii) gives
PbO (yellow) → PbO (red)
Therefore, $\Delta H = +217.3$ kJ/mol - 219.0 kJ/mol = -1.7 kJ/mol

Q-3: Graphite and diamond have combustion enthalpies of 393.5 and 395.4 kJ, respectively. Calculate the enthalpy change associated with the 1 mole of graphite transformed into diamond.

Answer: The combustion reactions of graphite and diamond are given below respectively:
i) $C(gr) + O_2(g) \rightarrow CO_2(g)$; $\Delta H = -393.5$ kJ/mol

ii) $C(dia) + O_2(g) \rightarrow CO_2(g)$; $\Delta H = -395.4$ kJ/mol

Aim: $C(gr) \rightarrow C(dia)$; $\Delta H = ?$

On reversing equation ii) and adding it to first we get
$C(gr) \rightarrow C(dia)$

$\Delta H = (-393.5 + 395.4)$ kJ/mol = 1.9 kJ/mol

Q-4: Why is the Hess law significant?
Answer: Hess law is significant because it can calculate heat changes for reactions that cannot be determined experimentally.

Q-5: According to Hess's law, a chemical reaction is independent of the path taken by chemical reactions while maintaining the same _____.

(a) Initial and Final Conditions
(b) Only the initial conditions
(c) Only the final conditions
(d) Temperature

Answer: a) According to Hess's law, a chemical reaction is independent of the path taken by chemical reactions while maintaining the same initial and final conditions.