Hess Law Chemistry Questions with Solutions

Q1. The variations in enthalpy that can not be detected per calorimeter can be seen with
(a) Hess law
(b) Ohm law
(c) Kreb law
(d) Newton law

Answer: (d) The variations in enthalpy that can not be detected in per calorimeter can be seen with the Hess law.

Q2. Hess's law states that a chemical reaction is independent of the route of chemical reactions while keeping the same
(a) Initial and Final Conditions
(b) Initial conditions only
(c) Final conditions only
(d) None of the above

Answer: (a) Hess's law states that a chemical reaction is independent of the route of chemical reactions while keeping the same initial and final conditions.

Q3. The application of the law of thermodynamics to the enthalpy change was discovered by
(a) Newton
(b) Einstein
(c) Hess
(d) None of the above

Answer: (c), The application of the law of thermodynamics to the enthalpy change was discovered by Hess.

Q4. If one or more modes bring about a chemical change in one or more steps, then the amount of heat absorbed or evolved during the entire reaction is the same, whichever way was obeyed. This law is known as
(a) Hess law
(b) Ohm law
(c) Kreb law
(d) Newton law

Answer: (a), If one or more modes bring about a chemical change in one or more steps, then the amount of heat absorbed or evolved during the entire reaction is the same, whichever way was obeyed. This law is known as Hess law.

Q5. The energy change in a chemical reaction and the surroundings at a constant temperature is known as
(a) Enthalpy
(b) Enthalpy profile
(c) Enthalpy change
(d) Enthalpy Dynamics

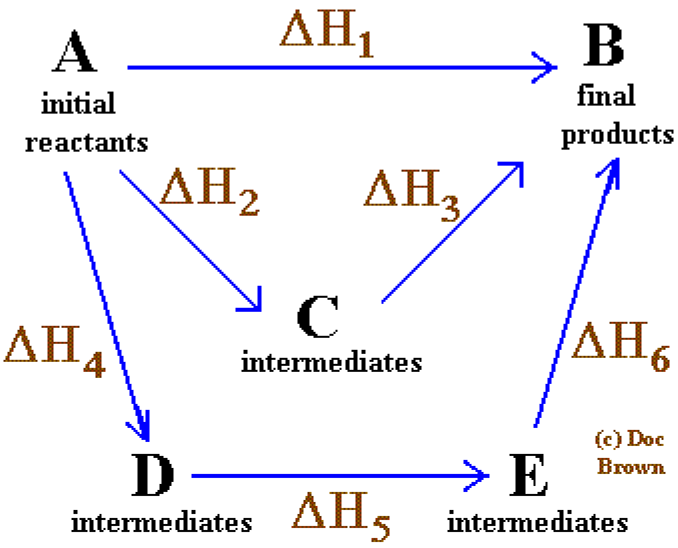
Answer: (c), The energy change in a chemical reaction and the surroundings at a constant temperature is known as enthalpy change.

Q6. Hess's law deals with
(a) Heat change in a chemical reaction
(b) Influence of pressure on the volume of gas
(c) Equilibrium constant
(d) Rate of reaction

Answer: (a) Hess's law deals with the heat change in a chemical reaction.

Q7. What is Hess law?

Answer: Hess law or Hess law of constant heat summation states that the amount of heat absorbed or evolved during the entire reaction is independent of the steps taken in the reaction.



Q8. Explain the feasibility of Hess law with an example.

Answer: Consider the formation of carbon dioxide. It can occur in two ways.
Method 1: Carbon reacts with oxygen to form carbon dioxide in a single step. It releases 94.3 kcals of heat.
$C + O_2 \rightarrow CO_2$ ($\Delta H = 94.3$ kcal)
Method 2: Carbon reacts with oxygen to form carbon monoxide in the first step. It releases 26.0 kcals of heat.
$2\,C + O_2 \rightarrow 2\,CO$ ($\Delta H_1 = 26.0$ kcal).
Carbon monoxide again reacts with oxygen to form carbon dioxide in the second step. It releases 68.3 kcals of heat.
$2\,CO + O_2 \rightarrow 2\,CO_2$ ($\Delta H_2 = 68.3$ kcal)
Adding the enthalpy of method two, $\Delta H_T = \Delta H_1 + \Delta H_2 = 26.0 + 68.3 = 94.3$ kcal.
Thus, the net reaction enthalpy of both reactions is the same as that of single-step formation. So, the enthalpy of the reaction does not change on the path followed by the reactants.
Thus, Hess's law is verified.

Q9. What is enthalpy?

Answer: Enthalpy is a thermodynamic parameter that measures the total heat present in a thermodynamic system where the pressure is constant.

Q10. What is entropy?
Answer: Entropy is the measure of the degree of randomness. It measures the system's thermal energy per unit temperature, which is elusive for doing useful work.

Q11. Calculate the standard enthalpy of formation of CH_3OH from the following data.

CH_3OH (l) + 2 O_2 (g) → CO_2 (g) + 2 H_2O (l) ($\Delta H = -726$ kJmpl^{-1})
C (graphite) + O_2 (g) → CO_2 (g) ($\Delta H = -393$ kJmol^{-1})
H_2 (g) + 2 O_2 (g) → H_2O (l) ($\Delta H = -286$ kJmol^{-1})

Answer: Reversing the equation 1.
CO_2 (g) + 2 H_2O (l) → CH_3OH (l) + 2 O_2 (g) ($\Delta H = +726$ kJmpl^{-1})
On reversing the reaction, the sign of ΔH also changes.
The second equation is
C (graphite) + O_2 (g) → CO_2 (g) ($\Delta H = -393$ kJmol^{-1}).
Multiply equation three by 2,
[H_2 (g) + 2 O_2 (g) → H_2O (l) ($\Delta H = -286$ kJmol^{-1})] X 2
2 H_2 (g) + 4 O_2 (g) → 2 H_2O (l) ($\Delta H = -286 \times 2 = -572$ kJmol^{-1})

Add these three equations.
C (graphite) + 2 H_2 (g) + ½ O_2 (g) → CH_3OH (l)

Enthalpy of formation of CH_3OH = ΔH_T
Enthalpy of formation of CH_3OH = $\Delta H_1 + \Delta H_2 + \Delta H_3$
Enthalpy of formation of CH_3OH = 726 - 393 - 572 $kJmol^{-1}$
Enthalpy of formation of CH_3OH = - 239 $kJmol^{-1}$

Q12. The enthalpies of formation CO (g), CO_2 (g), N_2O (g) and N_2O_4 (g) are − 110, − 393, 81 and 9.7 KJ/mol, respectively. Find the value of ΔH for the reaction.
N_2O_4 (g) + 3 CO → N_2O (g) + 3 CO_2 (g).

Answer: $\Delta H = 3\ \Delta CO_2 + 3\ \Delta N_2O - 3\ \Delta CO - \Delta\ N_2O_4$
$\Delta H = 3 \times (-393) + (81) - 3 \times (-110) - (9.7)$
$\Delta H = -\ (777.7)$ KJ

Q13. Calculate the enthalpy change for the following reaction:
CH_4 (g) + 2 O_2 (g) → CO_2 (g) + 2 H_2O (l).
Given that enthalpies of formation of CH_4, CO_2 and H_2O are 74.8 $kJmol^{-1}$,− 393.5 kJ mol^{-1}, and − 286 $kJmol^{-1}$, respectively.

Answer: $\Delta H^o = \Delta H^o_{(products)} - \Delta H^o_{(reactants)}$
$\Delta H^o = [\Delta H^o_{(CO2)} + 2 X \Delta H^o_{(H2O)}] - [\Delta H^o_{(CH4)} + 2 X \Delta H^o_{(O2)}]$
$\Delta H^o = [-\ 393.5 + 2 X (-286.2)] - [-74.8 + 2 X 0]$
$\Delta H^o = -\ 393.5 - 572.4 + 74.8$
$\Delta H^o = -\ 891.1$ kJ

Q14. Differentiate between enthalpy and entropy.
Answer:

S. No.	Enthalpy	Entropy
1.	**Enthalpy is a thermodynamic parameter that measures the total heat present in a thermodynamic system where the pressure is constant.**	**Entropy is a thermodynamic parameter that measures the system's thermal energy per unit temperature, which is elusive for doing useful work.**
2.	**It is the sum of internal energy and flows energy.**	**It is the measurement of the randomness of molecules**
3.	**It is denoted by the symbol H.**	**It is denoted by the symbol S.**
4.	**Its unit is Joule mol^{-1}.**	**Its unit is Joule K^{-1}.**

Q15. Differentiate between intensive and extensive functions.

Answer:

S. No.	Intensive Function	Extensive Function
1.	It does not depend on the mass.	It depends on the mass.
2.	It cannot be computed.	It can be computed.
3.	It is used to determine the identity of a system.	It can not be used to determine the identity of a system.
4.	It can be easily identified.	It cannot be easily identified.
5.	Example: Melting point, Boiling point, Freezing point, Colour, Lustre, Pressure, Density, Ductility, Conductivity, Odour, etc.	Example: Length, Weight, Mass, and Volume

Practise Questions on Hess law

Q1. One mole of a non-ideal gas undergoes a change state (2atm, 3L, 95K) to (4atm, 5L, 245K) with a change of internal energy, ΔU = 30 L atm. What is the change in enthalpy (ΔH) of the process in L atm?

Answer:

We know that,
$\Delta H = \Delta U + \Delta (PV)$
$\Delta H = 30 + (P_2V_2 - P_1V_1)$
$\Delta H = 30 + (4 \times 5 - 2 \times 3)$
$\Delta H = 30 + (20 - 6)$
$\Delta H = 30 + 14$
$\Delta H = 44$ L atm

Q2. The combustion of one mole of benzene occurs at 298 K, and 1 atm after combustion, CO_2 (g) and H_2O J are produced, and 3267.0 KJ of heat is liberated. Calculate the standard enthalpy of formulation ΔHf of benzene. The standard enthalpy of formation of CO_2 (g) and H_2O is - 393.5 KJ / Mole and - 285.83 KJ / Mole.

Answer: C_6H_6 (Benzene) + 15 / 2 O_2 → 6 CO_2 + 3 H_2O (ΔH_{rxn} = - 3267 KJ)
$\Delta H_{reaction} = 6\ \Delta HCO_2 + 3\ \Delta HH_2O - \Delta HC_6H_6$
$\Delta H_{(Benzene)} = 6 \times (-393.5) + 3\ (-285.8) + 3267$
$\Delta H_{(Benzene)} = -\ 3218.49 + 3267$
$\Delta H_{(Benzene)}$ = 48.51KJ

Q3. The reaction of cyanamide $NH_2CN(s)$ with dioxygen was carried out in a bomb calorimeter and $\triangle U$ was found to be −742.7 kJ mol^{-1} at 298 K.
NH_2CN (g) + 3 / 2 O_2 (g) → N_2 (g) + CO_2 (g) + H_2O (l)
Calculate the enthalpy change for the reaction at 298 K?

Answer: For the given reaction, $\Delta n = 1 + 1 - 1.5$
$\Delta n = = 0.5.$
$\Delta H = \Delta U + \Delta ngRT$
$\Delta H = -\ 742.7 + 0.5 \times 8.314 \times 10^{-3} \times 298$
$\Delta H = -\ 742.7 + 1.2$
$\Delta H = -\ 741.5$ kJ $mole^{-1}$

Q4. The enthalpy of vaporisation of water at 100°C is 40.63 KJ mol^{-1}. What is the value ΔE for this process?

Answer: We know that for gaseous reactants and products, we have a relation between the standard enthalpy of vapourisation (ΔH_{vap}) and standard internal energy (ΔE) as
$\Delta H_{vap} = \Delta E + \Delta_{ng}RT$
whereas,
$\Delta ng = n_2 - n_1$, i.e., the difference between no. of moles of reactant and product.
For vapourization of water,
H_2O (l) → H_2O (g)
$\therefore \Delta ng = 1 - 0$
$\Delta ng = 1$
T = 100 °C
T = (100 + 273)
T = 373 K
$\therefore \Delta H_{\ vap} = \Delta E + \Delta ngRT$
$\Delta E = \Delta H_{vap} - \Delta ngRT$
$\Delta E = 40.63 - (1 \times 8.314 \times 10^{-3} \times 373)$
ΔE = 37.53 KJ/mol
Hence the value of ΔE for this process will be 37.53KJ/mol.

Q5. The bond dissociation enthalpy of H2, Cl2 and HCl are 434, 242 and 431 kJ mol−1. What is the enthalpy of the formation of HCl?

Answer: The reaction between hydrogen and chlorine molecules forms hydrogen chloride.
H_2 (g) + Cl_2 (g) → 2 HCl (g)
We can break down this reaction into these simple steps:
Step 1: Dissociation of Hydrogen and Chlorine molecules into their individual atoms.
H_2 (g) → 2 H (g)
Cl_2 (g) → 2 Cl (g)
Step 2: Combination of these atoms to form hydrogen chloride.
2 H (g) + 2 Cl (g) → 2 HCl (g)
Since in the first step, one mole of each H−H and Cl−Cl bond is broken, it is an endothermic process. So, ($\Delta H_1 > 0$), while in the second step, two moles of HCl are being formed, which releases energy making $\Delta H_2 < 0$.
Now, $\Delta H_1 = \Delta H_{Cl-Cl} + \Delta H_{H-H}$
$\Delta H_1 = 434 + 242$
$\Delta H_1 = 676\ kJmol^{-1.}$
Now, $\Delta H_2 = -2\ \Delta H_{H-Cl}$
$\Delta H_2 = -\ 862\ kJmol^{-1}$
Applying Hess Law, i.e., $\Delta H = \Delta H_1 + \Delta H_2$, we get
$\Delta H = -\ 186\ kJmol^{-1}$
This is the enthalpy of the formation of two moles of HCl. Hence the enthalpy of formation of one mole of HCl will be
$\Delta H = -\ 186 / 2\ kJmol^{-1}$
$\Delta H = -\ 93\ kJmol^{-1}$