A-LEVEL

Questions for advanced-level chemistry on Thermochemistry.

1. Question: Define enthalpy and explain how it is different from internal energy.

Answer: Enthalpy (H) is the total heat content of a system, including internal energy (U) and the product of pressure and volume (PV). Enthalpy is a state function, whereas internal energy is the energy contained within a system and is also a state function. The relationship is given by the equation $H = U + PV$.

2. Question: Calculate the heat (in joules) released in the combustion of 5 moles of methane (CH_4) given that the enthalpy change is -802 kJ/mol.

Answer: The heat released (q) can be calculated using the formula $q = n\Delta H$, where n is the number of moles and ΔH is the enthalpy change. For 5 moles of CH_4, q = 5 moles * (-802 kJ/mol) = -4010 kJ.

3. Question: Explain the concept of bond dissociation enthalpy and how it is related to bond strength.

Answer: Bond dissociation enthalpy is the enthalpy change required to break a particular bond in one mole of a gaseous substance. Stronger bonds have higher bond dissociation enthalpies, as more energy is required to break them.

4. Question: Given the reaction: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, calculate the enthalpy change if 4 moles of ammonia (NH_3) are formed.

Answer: Using the coefficients in the balanced equation, the enthalpy change (ΔH) for the formation of 2 moles of NH_3 is the same as for 1 mole. Therefore, for 4 moles, $\Delta H = 2$ moles x ΔH.

5. Question: Explain how Hess's Law can be applied to calculate the enthalpy change for a reaction.

Answer: Hess's Law states that the total enthalpy change for a reaction is independent of the pathway taken. To calculate ΔH for a reaction, break it down into a series of steps with known ΔH values and sum them up.

6. Question: Define the standard enthalpy of formation ($\Delta H_f°$) and explain how it is determined.

Answer: ΔH_f° is the enthalpy change when one mole of a compound is formed from its elements in their standard states. It is determined experimentally through calorimetry, and values are tabulated for various compounds.

7. Question: Calculate the standard enthalpy change for the combustion of ethene (C_2H_4) given the following ΔH_f° values: $CO_2(g)$ = -393.5 kJ/mol, $H_2O(l)$ = -285.8 kJ/mol, $C_2H_4(g)$ = 52.3 kJ/mol.

Answer: The enthalpy change is given by ΔH = ΣΔH_f(products) - ΣΔH_f(reactants) = [2(-393.5) + (-285.8)] - 52.3 = -1156.1 kJ.

8. Question: Explain how temperature affects the spontaneity of a reaction using the Gibbs free energy equation.

Answer: The Gibbs free energy equation is ΔG = ΔH - TΔS, where ΔG is the Gibbs free energy, ΔH is the enthalpy change, T is the temperature, and ΔS is the entropy change. If ΔG is negative,

the reaction is spontaneous. Temperature influences spontaneity: at higher temperatures, a positive ΔS term becomes more significant, favoring spontaneity.

9. Question: Define entropy (S) and explain how it relates to the randomness of particles in a system.

Answer: Entropy is a measure of the disorder or randomness of particles in a system. A system tends to move towards a state with higher entropy, reflecting the tendency towards increased randomness.

10. Question: Calculate the change in entropy for the reaction: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ given the standard entropy values: $S°(H_2(g)) = 130.7$ J/(mol·K), $S°(O_2(g)) = 205.0$ J/(mol·K), $S°(H_2O(l)) = 69.9$ J/(mol·K).

Answer

The change in entropy (ΔS) is calculated as ΣS°(products) - ΣS°(reactants) = [2(69.9)] - [2(130.7) + 205.0] = -326.2 J/(mol·K).

11. Question: How does pressure influence the enthalpy change in a reaction, and why?

Answer: Pressure has a significant effect on the enthalpy change only for reactions involving gases. According to Le Chatelier's principle, increasing pressure favors the side with fewer moles of gas. Therefore, the enthalpy change depends on the change in the number of moles of gas in the reaction.

12. Question: Explain the concept of specific heat capacity and how it is related to temperature changes.

Answer: Specific heat capacity (C) is the amount of heat energy required to raise the temperature of one gram of a substance by one degree Celsius. It is related to temperature changes through the equation $q = mC\Delta T$, where

q is heat, m is mass, C is specific heat capacity, and ΔT is the temperature change.

13. Question: Calculate the heat (in joules) required to raise the temperature of 100 g of water from 25°C to 50°C. (Specific heat of water = 4.18 J/g·°C)

Answer: Using the formula q = mCΔT, where m is mass, C is specific heat capacity, and ΔT is the temperature change: q = 100 g x 4.18 J/g·°C x (50°C - 25°C) = 2090 J.

14. Question: Define calorimetry and explain how it is used to measure heat changes.

Answer: Calorimetry is the measurement of heat changes in chemical and physical processes. In a calorimeter, heat is transferred between the system and surroundings, and the temperature change is used to calculate heat flow. The heat capacity of the calorimeter is crucial for accurate measurements.

15. Question: Explain the concept of the standard molar entropy (S°) and its significance in thermodynamics.

Answer: Standard molar entropy (S°) is the entropy of one mole of a substance in its standard state. It reflects the degree of disorder in a substance. The higher the entropy, the more disordered the substance. S° is a key factor in determining the spontaneity of a reaction.

16. Question: Calculate the change in Gibbs free energy (ΔG) for a reaction at 25°C with ΔH = -150 kJ and ΔS = 200 J/K.

Answer: Using the equation ΔG = ΔH - TΔS, where ΔH is the enthalpy change, T is the temperature in Kelvin, and ΔS is the entropy change: ΔG = (-150,000 J) - (25°C + 273.15 K) x (200 J/K) = -150,000 J + 25,000 J = -125,000 J.

17. Question: Explain the concept of standard state in thermodynamics.

Answer: The standard state in thermodynamics is the state of a substance at a defined set of conditions: 1 atm pressure for gases, 1 M concentration for solutions, and a specified temperature (usually 25°C or 298.15 K). Standard state values are used to calculate thermodynamic properties.

18. Question: Define the terms "endothermic" and "exothermic" reactions, providing examples.

Answer: Endothermic reactions absorb heat from the surroundings, causing a temperature decrease. An example is the process of photosynthesis. Exothermic reactions release heat to the surroundings, causing a temperature increase. An example is the combustion of wood.

19. Question: Explain the relationship between enthalpy change (ΔH) and heat (q) in a chemical reaction.

Answer: Enthalpy change (ΔH) in a chemical reaction is equal to the heat (q) transferred at constant pressure. This relationship is based on the definition of enthalpy, which includes heat content.

20. Question: Given the reaction: $2C_{(s)} + 3H_{2(g)} \rightarrow C_2H_{6(g)}$, calculate the enthalpy change if 2 moles of ethane (C_2H_6) are formed, using the enthalpy change for the reaction.

Answer: If the enthalpy change for the reaction is, for example, -312 kJ, and the coefficients in the balanced equation are used, the enthalpy change for 2 moles of C_2H_6 is -312 kJ/2 = -156 kJ.