IB Chemistry: Energetics Practice Question [~30 marks]

Ethene Gas + Water => Ethanol Liquid

$C_2H_{4\,(g)} + H_2O_{\,(l)} => C_2H_5OH_{\,(l)}$

1. *Write a balanced equation [1 mark]*

$$C_2H_{4\,(g)} + H_2O_{\,(l)} => C_2H_5OH_{\,(l)}$$

2. *Explain the structure and bonding of ethane and ethanol [4 marks]*

- Draw the Lewis Diagrams for both Ethene and Ethanol
- List number of each type of bond (ie. 1 C=C and 4 C-H for Ethene)
- Describe bonds in terms of Sigma and Pi bonds
- State the bonding of each charge center (ie. sp^2 trigonal planar 120° for Ethene)
- State the types of IMFA's (ie. non-polar, LDF for Ethene)

3. *Explain what is meant by enthalpy of formation [2 marks]*

Definition: Energy released when 1 mol of ethanol is formed from 1 mol of Ethene Gas and 1 mol of Water Liquid.

4. *Write a balanced thermochemical equation for Ethanol given that ΔH_f = -277.7 kJ/mol [2 marks]*

$$2\,C_{(s)} + 3\,H_{2\,(g)} + ½\,O_{2\,(g)} => C_2H_5OH_{\,(l)} + 277.7kJ$$

5. *Calculate the enthalpy of the reaction using the data table. [2 marks]*

- Use the equation: $\Delta H_{rxn} = \Delta H_{products} - \Delta H_{reactants}$

6. *Outline what you understand based on your answer from 5. [2 marks]*

- Exothermic reaction
- Products more stable than reactants

7. *Predict the spontaneity of the reaction [2 marks]*

- Not spontaneous, entropy is decreasing since you go from (Solid + Gas) => Liquid
- Entropy of a gas is much greater than the entropy of a liquid

8. *Compare and contrast between $H_f°$ of $H_{2\,(g)}$ and the entropy of $H_{2\,(g)}$ [2 marks]*

- $H_f°$ is 0 since Hydrogen gas is an element (by convention it must be 0)
- ΔS of H_2 is not 0 (entropy is energy distributed in a system) therefore the entropy must have a numerical value.

9. *Explain what you understand about ΔS of the reaction [3 marks]*

- ΔS°
  - Δ means change
  - S means randomness & disorder of the system
  - ° means under standard conditions

10. *Calculate the ΔS of the given reaction and explain what you understand based on the answer. [3 marks]*

- ΔS is negative
- Use the equation $\Delta S_{reactants} = \Delta S_{products} - \Delta S_{reactants}$
- Since entropy change is negative the products are more ordered than the reactants
- This reaction is not spontaneous since entropy must always increase in a spontaneous reaction

11. *Would this reaction be spontaneous at room temperature? Justify. [4 marks]*

- Use the equation $\Delta G = \Delta H - T\Delta S$
- Not spontaneous at room temperature
- Reaction may occur at low temperatures since:
  - $\Delta G < 0$ for spontaneity
  - ΔS is negative (based on answers above)
  - ΔH is negative (based on answers above)
  - Therefore for ΔG to be negative, T must be very low
  - Therefore the reaction is only spontaneous at low temperatures (most likely not room temp)

12. *Calculate the temperature which this reaction is spontaneous. [3 marks]*

- Use the equation $\Delta G = \Delta H - T\Delta S$
- Set $\Delta G = 0$
- ΔH and ΔS already known from previous questions
- Solve for T
- Be careful to convert units to kJ