ANSWERS: Entropy change

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| **2019** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | The reaction has 9 moles of gaseous reactants and 10 moles of gaseous products. Increasing numbers of gaseous particles increases disorder, so the entropy of the system increases.  Since the process is exothermic, heat energy is released into the  surroundings increasing the disorder, so the entropy of the surroundings increases.  Therefore, the total entropy increases due to an increase in both the entropy of the system and the surroundings, so the reaction is spontaneous. | Recognises increasing  disorder / more particles.  OR  Reaction is exothermic so  heat is released. | Entropy changes of the system  OR  surroundings is explained.  OR  Partial explanation for both with  some linking of ideas. | Entropy changes of the system (reference to states) and surroundings explained and overall entropy change used to justify the spontaneous reaction. |

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| **2018** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | When ammonium chloride dissolves in water, the entropy of the system increases. This is because there are more moles of particles formed / the ions / particles in the solution are more disordered than the solid / greater random movement of products particles / a greater dispersal of matter and energy.  Since the process is endothermic, the entropy of the surroundings decreases because heat energy has been transferred from the surroundings so there is decreased random motion of the / decrease in the dispersal of matter and energy.  However, since the NH4Cl readily dissolves in water / process occurs spontaneously, the total entropy change is positive / total entropy increases/ increase in entropy of system outweighs decrease of entropy in the surroundings. | • Identifies change in entropy for BOTH the system and the surroundings.  • Recognises entropy is a measure of the random motion of particles / dispersal of matter and energy / measure of disorder. | • Explains entropy change for the system.  OR  Explains entropy change for the surroundings. | • Full justification why NH4Cl dissolves in water in terms of entropy changes of the system  AND the surroundings. |

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| **2017** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| **(a)** | System – as the number of gaseous molecules is greater on the product side than the reactant side, then there is an increase in disorder / the dispersal of matter / degree of randomness / dispersal of energy, thus the entropy of the system increases.  Surroundings – as the reaction is exothermic the entropy of the surroundings increases, as there is an increase in disorder / the dispersal of matter / degree of randomness / dispersal of energy. | • One correct statement. | Explains the entropy changes in the system / surroundings  OR  a partial explanation of both. | Explains the entropy changes of the system and the surroundings. |
| **(b)** | Spontaneity is determined by the total entropy change (system + surroundings).  Entropy of the system increases as the solid becomes a gas because the gas particles are more disordered.  The increase in entropy of the system outweighs the decreased entropy of the surroundings due to the positive enthalpy  OR positive enthalpy due to the endothermic process of breaking bonds is offset by entropy changes in the  system. | • ONE Correct statement. | Links entropy of system to sublimation  OR  Links positive enthalpy to entropy of surroundings  OR  Contrast entropy of system to entropy of surroundings. | Complete explanation of entropy and enthalpy considerations linked to spontaneity of sublimation process. |

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| **2016** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | When solid NaCl dissolves in water, there is an increase in the entropy of the system since the ions in solution have greater entropy than in the solid lattice, i.e. more random / disordered arrangement. Although the ions in solution have more energy / energetically less stable than in the solid lattice (since the process is endothermic), the increase in entropy makes the process spontaneous. | • Identifies entropy of system increases / positive entropy change. | • Links an increase in entropy to an increased random arrangement of particles. | • Full explanation |

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| **2014** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | Positive; or entropy increases. Ions in solution (generally) have higher entropy than solids as there is an increase in the dispersal of matter / degree of disorder. | * Correct change. | * Correct change and explanation. |  |
|  | |  |  | | --- | --- | | **🗸** | The entropy of the system increases | |  | The entropy of the surroundings increases | |  | The entropy of the system decreases | | **🗸** | The entropy of the surroundings decreases |   As a solid is converted into a gas, the entropy of the system increases due to the greater dispersal of matter, as the random motion of the gases is higher.  The entropy of the surroundings decreases because heat is transferred from the surroundings. This results in less random motion of the particles in the surroundings. | * Ticks both correct.   OR  Outlined in the justification. | * One explanation. | • One explanation. |

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| **2013** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | Enthalpy change: The combustion of liquid hydrazine is an exothermic process since Δc*H*° is negative. Exothermic reactions form products that have lower energy than the reactants / energy is released and this favours the spontaneous / forward reaction.  Entropy change: Exothermic reactions release heat to the surroundings, which makes the entropy change of the surroundings positive. As both the surroundings and the system gain entropy, this favours the spontaneous / forward reaction.  OR  The combustion reaction has more gas molecules in the products / goes from liquid to gas / increase in number of particles. Therefore the entropy of the system increases and this favours the spontaneous / forward reaction.  As both enthalpy and entropy are favoured, then hydrazine readily burns / the reaction is spontaneous. | * Recognises entropy increases which favour the reaction.   OR  Recognises reaction is exothermic which favours the reaction. | * Partial explanation refers to both entropy and enthalpy changes.   OR  Full explanation for enthalpy or entropy change. | • Full explanation. |

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