AS91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

Collated Entropy Questions

2025:1

(c) Finely powdered sulfur, S(s), readily reacts with fluorine gas, $F_2(g)$, in an exothermic reaction to produce sulfur hexafluoride, $SF_6(g)$. The equation for the reaction is:

$$S(s) + 3F_2(g) \rightarrow SF_6(g)$$

Justify, in terms of the entropy changes of the system and surroundings, why the reaction is spontaneous.

2024:1

(b) (ii) The reaction between chlorine trifluoride, $ClF_3(g)$, and hydrazine, $N_2H_4(l)$, is explosive. It was investigated as a potential rocket fuel.

Justify, in terms of the entropy changes of the system and the surroundings, why the reaction between chlorine trifluoride and hydrazine is spontaneous.

$$4ClF_3(g) + 3N_2H_4(l) \rightarrow 12HF(g) + 3N_2(g) + 2Cl_2(g)$$

2023:1

(c) (iii) The reaction shown below of hydrazine reacting with oxygen is exothermic.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

Justify, in terms of the entropy changes of the system and surroundings, why the reaction is spontaneous.

2022: 2

(c) When diborane, B_2H_6 , reacts with oxygen, O_2 , it catches fire. The reaction is given below:

$$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(l)$$

(ii) Justify, in terms of the entropy changes of the system and the surroundings, why the reaction occurs spontaneously.

2021:1

(c) Potassium nitrate, KNO_3, readily dissolves in water according to the equation below:

$$KNO_3(s) \rightarrow K^+(aq) + NO_3^-(aq) \quad \Delta_rH^\circ = +34.9 \text{ kJ mol}^{-1}$$

(i) Justify, in terms of the entropy changes of the system and the surroundings, why the reaction is spontaneous.

2020:2

(c) When solid calcium, Ca(s), is added to a test tube of hydrochloric acid solution, HCl(aq), the calcium reacts vigorously. The test tube becomes hot, and bubbles of hydrogen gas, $H_2(g)$, are released. The reaction can be represented by the equation below:

$$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$$

Justify, in terms of the entropy changes of the system and the surroundings, why the reaction is spontaneous.

2019:3

(d) Ammonia reacts with oxygen according to the equation below.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \quad \Delta_r H° = -906 \text{ kJ mol}^{-1}$$

Justify, in terms of the entropy changes of the system and surroundings, why the reaction is spontaneous.

2018:3

(c) The dissolving of ammonium chloride in water is an endothermic process, but ammonium chloride readily dissolves in water.

$$NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$$

Justify, in terms of the entropy changes of the system and the surroundings, why ammonium chloride readily dissolves in water.

2017:2

(d) The reaction for the complete combustion of hydrazine is shown in the equation below.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

This is an exothermic reaction. Explain the entropy changes associated with this reaction

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2017:3

(b) (iii) Explain why the sublimation of iodine is spontaneous, even though the enthalpy of sublimation is a positive value.

2016:2

(c) (iii) Why does NaCl readily dissolve in water, even though the process is slightly endothermic?
$NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ $\Delta r\ H° = +3.90 \text{ kJ mol}^{-1}$

2016:3

(b) (iii) The equation for the evaporation of liquid methanol is:

$CH_3OH(l) \rightarrow CH_3OH(g)$

Explain the entropy changes of the system and surroundings for the evaporation of methanol.

2015

No question

2014:3

(b) Ammonium nitrate is used in 'cold packs' to relieve symptoms of a sports injury. The dissolving of the solid crystals of ammonium nitrate (shown in the equation below) is spontaneous, despite being endothermic.

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

Explain why this is so, in terms of the entropy change for the reaction system.

(c) Ammonium nitrate dissociates in an endothermic reaction, as shown in the equation below.

$$NH_4NO_3(s) \rightarrow NH_3(g) + HNO_3(g)$$

Below is a table outlining four statements about changes in entropy that may occur during any reaction. Tick (✓) to the left of any statement that is correct for the above reaction.

Tick (✓)	Entropy statement
	The entropy of the system increases.
	The entropy of the surroundings increases.
	The entropy of the system decreases.
	The entropy of the surroundings decreases.

Justify your choice(s)

2013:3

(c) Hydrazine is often used as a rocket fuel. When liquid hydrazine undergoes combustion, it forms nitrogen and water:

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta_cH°(N_2H_4(l)) = -624 \text{ kJ mol}^{-1}$$

Explain why liquid hydrazine readily burns in oxygen. Your answer should consider both enthalpy and entropy changes

ANSWERS

2025:1

(c) *The entropy of the system decreases since three highly randomised, disordered gaseous molecules and one more ordered solid produce only one gas molecule. So, there is less dispersal of matter and energy in the system. Since the reaction is exothermic, this means heat energy is released into the surroundings, so the particles in the surroundings gain heat energy / kinetic energy. As a result, there is greater dispersal of matter and energy in the surroundings, so the entropy of the surroundings increases. Because the reaction is spontaneous, the increase in entropy of the surroundings must outweigh the decrease in entropy of the system, making the overall entropy change positive.*

2024:1

(b) (ii) *The entropy of the system increases since 4 highly randomised, disordered gaseous molecules and 3 more ordered liquid molecules produce 17 highly randomised, disordered gaseous molecules. So, there is greater dispersal of matter and energy in the system. Since the reaction is exothermic (reaction is explosive), heat energy is released into the surroundings, so the particles in the surroundings gain heat energy / kinetic energy. As a result, there is greater dispersal of matter and energy in the surroundings, so the entropy of the surroundings increases. The increase in entropy of the system and of the surroundings makes the overall entropy change positive, so the reaction is spontaneous.*

2023:1

(c) (iii) *The entropy of the system increases since the liquid hydrazine forms gaseous products and the number of molecules increases from two reactants to three products. This means there is a greater dispersal of matter and energy in the system.*

Since the reaction is exothermic, this means heat energy is released into the surroundings, so particles in the surroundings gain heat energy / kinetic energy / move faster. This results in a greater dispersal of matter and energy in the surroundings, so the entropy of the surroundings increases.

Since the entropy of both the system and the surroundings increases, this means the total entropy change will be positive and therefore the reaction will be spontaneous.

2022:2

(c) (ii) *The entropy of the system decreases since four highly randomised, disordered gaseous molecules produce four more ordered solid and liquid molecules. So, there is less dispersal of matter and energy in the system.*

Since the reaction is exothermic (borane catches fire when it reacts with oxygen), this means heat energy is released into the surroundings, so the particles in the surroundings gain heat energy / kinetic energy. As a result, there is greater dispersal of matter and energy in the surroundings, so the entropy of the surroundings increases.

Because the reaction is spontaneous, the increase in entropy of the surroundings must outweigh the decrease in entropy of the system making the overall entropy change positive.

2021:

(c) (i) The ordered K^+ ions and NO_3^- ions in the solid lattice form disordered K^+ ions and NO_3^- ions in solution. As a result, there is a greater dispersal of matter and energy in the system / more disorder, so the entropy of the system increases (positive entropy change).

Since the reaction is endothermic, heat energy is absorbed from the surroundings. As a result, there is a decrease in the dispersal of matter and energy / disorder in the surroundings, so the entropy of the surroundings decreases (negative entropy change).

Given that potassium nitrate readily dissolves in water / reaction is spontaneous, the increase in entropy of the system must be greater than the decrease in entropy of the surroundings, therefore the total entropy change will be positive.

2020:2

(c) *The entropy of the system increases since the ordered solid Ca particles produce disordered hydrogen gas molecules. So, there is a greater dispersal of matter and energy in the system. The reaction is exothermic (as evidenced by the test tube becoming hot). This means heat energy is released into the surroundings, so the air particles gain heat energy / kinetic energy. As a result the entropy of the surroundings increases. Since the entropy of both the system and the surroundings increases, this means the total entropy change will be positive and therefore the reaction will be spontaneous.*

2019:3

(d) *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.*

2018:3

(c) *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 NH_4Cl 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.

2017:2

(d) *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.

2017:3

(b) (iii) *$I_2(s) \rightarrow I_2(g)$ 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.*

2016:2

(c) (iii) *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.*

2016:3

(b) (iii) *There is an increase in entropy since gaseous particles are formed; gaseous particles have a more random / disordered arrangement (greater dispersal of matter) than liquid particles. The enthalpy of the surroundings decreases as the alcohol evaporates as energy is absorbed from the surroundings to break the intermolecular forces between methanol molecules; thus the entropy of the surroundings decreases.*

2014:3

(b) *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.*

(c)

Tick (✓)	Entropy statement
✓	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.

2013:3

(c) *Enthalpy change: The combustion of liquid hydrazine is an exothermic process since $\Delta_c H°$ 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.