

Exercise walk-through

9.1

Introduction to Entropy

AP Chemistry

Entropy

Entropy S measures how spread out matter and energy are among **microstates**. $\Delta S > 0$ for more freedom:

- solid $\rightarrow$ liquid $\rightarrow$ gas
- dissolving a solid
- more gas molecules

Products minus reactants

$$\Delta S^\circ = \sum S^\circ(\text{prod}) - \sum S^\circ(\text{react})$$

Gases have the highest S° ; a reaction making a gas has $\Delta S > 0$.

When entropy increases

entropy S

measures the dispersal of energy and matter – loosely, the **number of ways** to arrange a system

phase

increases solid $\rightarrow$ liquid $\rightarrow$ gas, and the gas step is by far the largest

particle count

more moles of gas on the product side means $\Delta S > 0$

dissolving

usually increases entropy, as an ordered lattice disperses

temperature

raising it increases entropy, because more energy levels become accessible

volume

expanding a gas increases it

Count the **moles of gas** on each side first. That single comparison predicts the sign of ΔS for most reactions on the paper.

Exercises 2.1-2.3

2.1 Rank solid, liquid, and gas by entropy.

[1]

2.2 State the sign of ΔS when a liquid boils.

[1]

2.3 State the sign of ΔS for $2\text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$ (2 gas moles $\rightarrow$ 1).

[1]

Exercises 2.1-2.3

2.1 Rank solid, liquid, and gas by entropy. [1]

2.1

- gas > liquid > solid
-

2.2 State the sign of ΔS when a liquid boils. [1]

2.2

- Positive ($\Delta S > 0$)
-

2.3 State the sign of ΔS for $2\text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$ (2 gas moles $\rightarrow$ 1). [1]

2.3

- Negative (fewer gas moles)

Exercise 3.1

3.1 Which process has $\Delta S > 0$?

[1]

☐

A gas condensing to liquid

B water freezing

C a solid subliming to gas

D 2 gas moles forming 1 gas mole

Exercise 3.1

3.1 Which process has $\Delta S > 0$?

[1]

☐

A gas condensing to liquid

B water freezing

C a solid subliming to gas

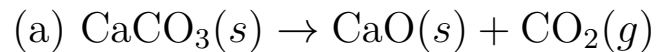
D 2 gas moles forming 1 gas mole

3.1 C

- subliming a solid to gas greatly increases disorder

Exercise 3.2 (a)

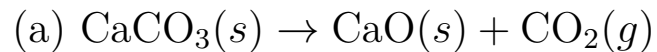
3.2 Predict the sign of ΔS for each:



[1]

Exercise 3.2 (a)

3.2 Predict the sign of ΔS for each:



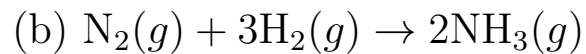
[1]

(a)

- positive (a gas is produced)

Exercise 3.2 (b)

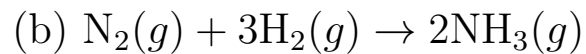
3.2 Predict the sign of ΔS for each:



[1]

Exercise 3.2 (b)

3.2 Predict the sign of ΔS for each:



[1]

(b)

- negative (4 gas moles
- 1.

Exercise 3.2 (c)

3.2 Predict the sign of ΔS for each:

(c) dissolving salt in water

[1]

Exercise 3.2 (c)

3.2 Predict the sign of ΔS for each:

(c) dissolving salt in water

[1]

(c)

- positive

Exercise 3.3

3.3 Explain, in terms of arrangements, why a gas has higher entropy than the same substance as a solid. [2]

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3.3

- A gas has vastly more available positions and energy arrangements than a rigid, ordered solid, so far more microstates – hence higher entropy