 Module 4: Entropy and Gibbs free energy

Year 11 chemistry 2018

Duration – 10 hours

This document references the [Chemistry Stage 6 Syllabus](https://syllabus.nesa.nsw.edu.au/chemistry-stage6/) © 2017 [NSW Education Standards Authority (NESA)](http://syllabus.nesa.nsw.edu.au/copyright/) for and on behalf of the Crown in right of the State of New South Wales.

Inquiry question

How can enthalpy and entropy be used to explain reaction spontaneity?

Rationale

Students explore the differences between enthalpy and entropy and use balanced equations to predict an increase or decrease in entropy. Students explore the concept of spontaneity; and learn how to uses Gibbs free energy formula to predict the spontaneity of reactions.

Outcomes

Working scientifically skills

* CH11-1 Develops and evaluates questions and hypotheses for scientific investigation
* CH11-5 Analysing data and information analyses and evaluates primary and secondary data and information
* CH11-6 Problem solving solves scientific problems using primary and secondary data, critical thinking skills and scientific processes
* CH11-7 Communicating communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Knowledge and understanding

* CH11-11 analyses the energy considerations in the driving force for chemical reactions

Depth study

* Identification of Chemists involved in thermodynamic theory development.
* How do micro and macro states affect entropy?
* How is entropy influenced by temperature?
* How does temperature affect reaction spontaneity?

Assessment

* Formative assessment of depth Study

Resources

* [What drives spontaneous change?](http://www.chem1.com/acad/webtext/thermeq/TE1.html#SEC1)
* [Entropy game](https://www.etc.cmu.edu/projects/entropy/)
* [The entropy of it all](http://www.cpalms.org/Public/PreviewResourceLesson/Preview/75658)
* [Thermodynamics](https://msu.edu/~carpen87/assignments/Unit%20Plan%201.pdf)
* [Entropy powerpoint](https://www.tes.com/teaching-resource/entropy-powerpoint-11042944)
* [Entropy lesson](https://www.ck12.org/book/CK-12-Chemistry-Second-Edition/r6/section/22.4/)
* [Gibbs free energy](http://study.com/academy/lesson/gibbs-free-energy-definition-significance.html)
* [Entropy and enthalpy changes](http://highschoolenergy.acs.org/content/hsef/en/energy-theories/entropy-enthalpy/_jcr_content/toparticleparsys/columnsbootstrap/column1/acscontainer/containerPar/download/file.res/Teacher's_Key.pdf) – lab investigation

Content

The working scientifically skills mentioned in the outcomes should be embedded throughout the teaching and learning experiences

CH11-11 analyses the energy considerations in the driving force for chemical reactions

Students:

* analyse the differences between entropy and enthalpy
* use modelling to illustrate entropy changes in reactions
* predict entropy changes from balanced chemical reactions to classify as increasing or decreasing entropy
* explain reaction spontaneity using terminology, including: (ACSCH072)
  + Gibbs free energy
  + enthalpy
  + entropy
* solve problems using standard references and (Gibbs free energy formula) to classify reactions as spontaneous or nonspontaneous
* predict the effect of temperature changes on spontaneity (ACSCH070)

| Teaching and learning | Evidence of learning |
| --- | --- |
| Revise the first law of thermodynamics - Energy cannot be created nor destroyed only transformed  Watch: [embrace the chaos : crash course chemistry #20](https://www.youtube.com/watch?v=ZsY4WcQOrfk)  Watch: [What is entropy? - Jeff Phillips](https://www.youtube.com/watch?v=YM-uykVfq_E)  Define the terms:   1. Enthalpy (H) - a thermodynamic quantity equivalent to the total heat content of a system. It is equal to the internal energy of the system plus the product of pressure and volume. 2. Entropy (S) - a thermodynamic quantity representing the unavailability of a system's thermal energy for conversion into mechanical work, often interpreted as the degree of disorder or randomness in the system.   Analyse the difference between enthalpy and entropy  Perform some simple modelling of entropy   * [Flipping ten coins](http://www.chem1.com/acad/webtext/thermeq/TE1.html#SEC) * Watch: [Illustrating Entropy](https://www.youtube.com/watch?v=P9eksvw2e6w) * Construct a diagram of molecules in ice, water and steam and compare the changes in entropy.   + Students can model this physically by role playing molecules and acting like a solid, liquid or gas. Students compare the differences between each state. | Define first law of thermodynamics.  Analyse of difference between entropy and enthalpy.  Recall and observe some models of how entropy changes in reactions. |
| Define terms   1. microstate - a specific way in which we can arrange the energy of the system. Each atom within a system is a microstate of that system 2. macrostate - Comprised of many microstates which determine the overall properties of the system including temperature, pressure and volume.   Identify that macro state contains many micro states  Examples   * Child’s Toy room example - always moves to a state of disorder, there is only one organised state every other is disorganised, each toy is a microstate * What is the probability of landing 0-10 heads from 10 coins, tabulate all combinations - link each coin to a microstate and whole group as macrostate. * Checker board coin flip activity - Fill a checkerboard with red checkers then flip a coin, heads change checker to black. - it is more likely that a state of increased disorder (entropy) is established once coins are flipped can relate each checker to microstate * Observe [simulation of entropy, microstates and probability demonstration](https://phet.colorado.edu/en/contributions/view/3948)   Discussion on the size of these examples compared to that in a chemical system | Identify that macrostates contain many microstates and that higher probability events are more disordered. |
| Watch: [Predict the entropy change for a given reaction or process](https://www.youtube.com/watch?v=ro3AnXdajAM)  Predict entropy changes in reactions.  Classify entropy changes as increasing or decreasing entropy  Some examples could include:        Solve problems to balance chemical equations and determine change in entropy of reactions. Examples must include states of matter.  [Example worksheet](https://www.saddleback.edu/faculty/cabel/Saddleback/Chapter17_files/chem1b-ws14-s-g.pdf)  [Answers](https://www.saddleback.edu/faculty/cabel/Saddleback/Chapter17_files/chem1b-ws14-s-g-key.pdf) | Correctly predict entropy changes in chemical reactions and classify as increasing or decreasing entropy. |
| Calculate the change in entropy for reactions using  (products) -  (reactants)  Some examples could include:        Calculate the change in enthalpy for reactions using  (products) -  ΣH°(reactants)  Some examples could include:        Solve problems to determine reaction entropy.  [NESA chemistry data sheet](https://syllabus.nesa.nsw.edu.au/assets/chemistry/files/chemistry-formulae-sheet-data-sheet-periodic-table-hsc-exams-2019.pdf) (approved) and [standard enthalpies and standard entropies of common compounds](http://www.mrbigler.com/misc/energy-of-formation.PDF)  [Example worksheet](http://fileserver.net-texts.com/asset.aspx?dl=no&id=10124) | Solve problems to determine reaction entropy for a range of reaction types. |
| Define the terms spontaneous and non-spontaneous reactions.   1. Spontaneous reaction - spontaneous reactions occur without outside intervention 2. Non-spontaneous - a reaction that is not spontaneous   Example reactions:   * Magnesium and dilute acid (spontaneous) compared to Copper and dilute acid (non-spontaneous) * Exothermic compared to endothermic reactions   Define Gibbs Free energy using equation and identify all values in the equation.  Use the standard references to substitute values into the equation. | Define the terms spontaneous and non-spontaneous reactions.  Define Gibbs Free energy using equation and identify all values in the equation.  Use the standard references to substitute values into the equation. |
| Define the term spontaneity.  Include chemical definition  is non-spontaneous,  is spontaneous  Watch: [The Laws of Thermodynamics, Entropy, and Gibbs Free Energy](https://www.youtube.com/watch?v=8N1BxHgsoOw&t=3s)  Watch: [Gibbs free energy and spontaneous reactions](https://www.youtube.com/watch?v=CHHu-iTwHjg)  Solve problems using standard references and  to classify reactions as spontaneous or nonspontaneous. | Use Gibbs Free Energy equation to explain reaction spontaneity.  Solve problems to classify reactions as spontaneous or nonspontaneous. |
| Students conduct a first-hand investigation to observe the effects of temperatures on entropy.  Example: Students observe aluminium placed into three beakers of different temperature dilute HCl and record reaction rate.  Possible depth study questions:   * How is entropy influenced by temperature? * How does temperature affect reaction spontaneity? | Conduct a first-hand investigation to observe the effects of temperatures on entropy. |

Reflection and evaluation: