

## **Instructors Guide for Concept Map Assignment Implementation**

### Overview

Studies of previous concept map implementation require significant training for both instructors and TAs for successful learning. This is an instructor's guide for the streamlined implementation of the concept map assignment. The primary objectives for this technique are:

- 1) Improved conceptual understanding of course material.
- 2) Student appreciation of chemistry concepts and how they relate to material inside and outside of the course.

### Concept Map implementation

Students should be provided with instruction of how to use and develop concept maps. For our implementation, the Cmap program was utilized and an instructional video was provided to show students the basic tools of the program. Cmap is a free program which can be downloaded at <https://cmap.ihmc.us/>. Students should be provided an example of how to develop a concept map. This can be completed as an in class-activity or online assessment. Emphasis should be placed on students feeling comfortable developing a map and using their own words for connecting concepts rather than specific connections provided by the instructor. Informing students that there is no one correct way to link a concept from one to another is important to not prevent unique individual thinking. Providing an example of how to incorrectly link a concept may provide students with an example of the types of errors they should avoid. It may be of benefit to use a non-chemistry topic to facilitate this understanding of concept map development. Students should also be encouraged to not feel limited to material discussed in only the chemistry course as they are most likely taking other STEM related subjects. Students can and should feel free to add connections between these STEM subjects and chemistry to help students build a broader map of how the STEM fields connect. Collection of the concept maps in our implementation was done through ilearn (blackboard) recitation sections. The student saved the concept maps as .pdf files and uploaded these to weekly discussion folders. Set-up of this can be completed by the instructor or TA depending on who will be reviewing the concept maps for review and grading.

### Concept Map Assignment and Grading

The concept map assignment should run the length of the course. Students should be encouraged to develop concept maps weekly as both study material and as review of the weekly

material. As students develop this concept map, it is important to stress that the action of building a concept map is a form of studying and a great study tool for midterms or quizzes throughout the course. By the end of the course students should have a complete comprehensive map which is a great study tool for the concepts on the final exam. Students and TAs can have been shown to have significant pushback on the concept map assignment. Additionally, a subjective grading scheme is likely to deter students from completing concept maps as they may not know what to do to receive points. As such, less pushback was observed if the concept map assignment if it is given as an extra credit assignment. This approach provides students with an incentive to complete the assignment for both their grade and improved conceptual understanding.

For TAs, it is important that the TAs are proficient in understanding how to develop concept maps. This should not require more than an hour of discussion of what the concept maps are and how students will be developing them. Provide the TAs with a completed concept map so they can reference important connections but be sure to emphasize that there are other possible correct answers. The TAs can use these concept maps to review student concept maps to determine which concepts may be important for further discussion in subsequent recitations or lectures.

If assessment of these concepts is desired, a less subjective method should be implemented. One such example would be the use of close-ended questions about the concepts for the week. The completion of the concept map should be tied to the questions in this assessment to encourage completion of the concept mapping assignment.

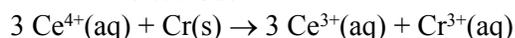
#### In-class review and discussion

The concept map assignment is designed for easy implementation into current and existing instructors teaching styles. Following review of the concept maps that are turned in each week, concepts which students are having a particularly difficult time determining connections for will become apparent. Once these concepts are identified, these concepts should be discussed further. This can be accomplished in either the subsequent lecture or in TA led recitation sections. The TA/instructor should not provide students with the answer but pose questions which will lead to student discussion and deepen understanding of the concepts. After a few weeks of concept map development by the students, or after the first exam, students should be shown an instructor completed concept map (completed by instructor is preferred). This will reinforce where they

should be with their concept maps and provide students once more with confidence that what they are working on is correct or the areas they need to improve. This does not have to be completed over an entire class period, but rather a short 5 to 10-minute discussion as to provide confidence to the students in their concept mapping skills.

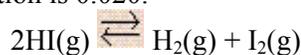
### Concept Inventory Questions (16 Points)

1. In a galvanic cell in which the following spontaneous reaction takes place, what process occurs at the cathode?



- (a) Reduction of  $\text{Cr}^{3+}(\text{aq})$
- (b) Reduction of  $\text{Ce}^{4+}(\text{aq})$
- (c) Reduction of  $\text{Cr}(\text{s})$
- (d) Reduction of  $\text{Ce}^{3+}(\text{aq})$

2. At  $445^\circ\text{C}$ ,  $K_c$  for the following reaction is 0.020.



A mixture of  $\text{H}_2$ ,  $\text{I}_2$ , and  $\text{HI}$  in a vessel at  $445^\circ\text{C}$  has the following concentrations:  $[\text{HI}] = 2.0 \text{ M}$ ,  $[\text{H}_2] = 0.50 \text{ M}$  and  $[\text{I}_2] = 0.10 \text{ M}$ . Which one of the following statements concerning the reaction quotient,  $Q_c$ , is **TRUE** for the above system?

- (a)  $Q_c = K_c$ ; the system is at equilibrium.
- (b)  $Q_c$  is less than  $K_c$ ; more  $\text{H}_2$  and  $\text{I}_2$  will be produced.
- (c)  $Q_c$  is less than  $K_c$ ; more  $\text{HI}$  will be produced.
- (d)  $Q_c$  is greater than  $K_c$ ; more  $\text{H}_2$  and  $\text{I}_2$  will be produced.
- (e)  $Q_c$  is greater than  $K_c$ ; more  $\text{HI}$  will be produced.

3. For a specific reaction, which of the following statements can be made about  $K_c$ , the equilibrium constant?

- (a) It always remains the same at different reaction conditions unless the temperature is changed.
- (b) It changes with changes in pressure.
- (c) It increases if the concentration of one of the products is increased.
- (d) It increases if the concentration of one of the reactants is increased.
- (e) It may be changed by the addition of a catalyst.

4. Consider the equilibrium system:



Which of the following changes will increase the total amount of  $\text{Cl}_2$  that can be produced?

- (a) removing some of the  $\text{I}_2\text{(s)}$
- (b) adding more  $\text{ICl(s)}$
- (c) removing the  $\text{Cl}_2$  as it is formed
- (d) decreasing the volume of the container

5. Which of the following would you predict to be the strongest acid?

- (a)  $\text{H}_2\text{SO}_3$ ;  $K_a = 1.54 \times 10^{-2}$
- (b)  $\text{HNO}_2$ ;  $K_a = 4.0 \times 10^{-4}$
- (c)  $\text{CH}_3\text{COOH}$ ;  $K_a = 1.76 \times 10^{-5}$
- (d)  $\text{HF}$ ;  $K_a = 7.2 \times 10^{-4}$
- (e)  $\text{HIO}_3$ ;  $K_a = 1.6 \times 10^{-1}$

6. Which of the following solutions has the lowest pH at  $25^\circ\text{C}$ ?

- (a) 0.2 M sodium hydroxide  $K_a = 1 \times 10^{-13}$
- (b) 0.2 M hypochlorous acid  $K_a = 2.9 \times 10^{-8}$
- (c) 0.2 M ammonia  $K_a = 5.8 \times 10^{-10}$
- (d) 0.2 M benzoic acid  $K_a = 6.3 \times 10^{-5}$
- (e) pure water  $K_a = 1 \times 10^{-7}$

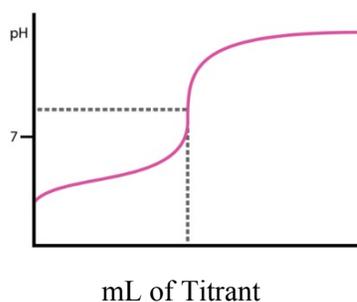
7. Which of the following statements would be **TRUE** if an aqueous base was added to pure water?

The self-dissociation constant for water is provided:  $K_w = [\text{OH}^-][\text{H}_3\text{O}^+]$

- (a) The self-dissociation constant for water ( $K_w$ ) would decrease.
- (b) The concentration of  $\text{H}_3\text{O}^+$  would decrease.
- (c) The concentration of  $\text{OH}^-$  would decrease.
- (d) There would be no change in the concentration of  $\text{H}_3\text{O}^+$  or  $\text{OH}^-$ .

8. Consider a 1.0 L solution which is 0.10 M in  $\text{CH}_3\text{COOH}$  and 0.20 M in  $\text{NaCH}_3\text{COO}$ . Which of the following statements is **TRUE**?
- (a) If a small amount of  $\text{NaOH}$  is added, the pH decreases very slightly.
  - (b) If  $\text{NaOH}$  is added, the  $\text{OH}^-$  ions react with the  $\text{CH}_3\text{COO}^-$  ions.
  - (c) If less than 0.10 moles of  $\text{HCl}$  added the pH will change slightly.
  - (d) If  $\text{HCl}$  is added, the  $\text{H}^+$  ions react with  $\text{CH}_3\text{COOH}$  ions.
  - (e) If more  $\text{CH}_3\text{COOH}$  is added, the pH increases.

9. The following titration curve is the kind of curve expected for the titration of a \_\_\_\_ acid with a \_\_\_\_ base.

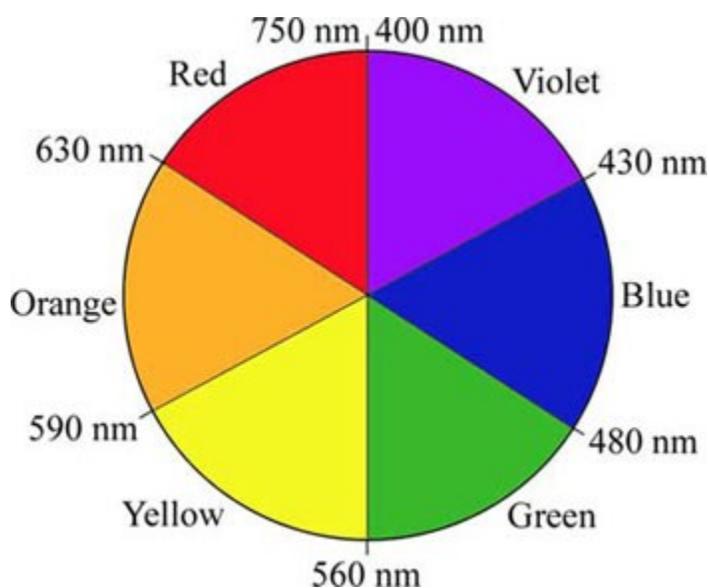


- (a) strong, strong
- (b) weak, strong
- (c) strong, weak
- (d) weak, weak

10. If you use  $x$  to represent the molar concentration of silver(I) and  $y$  to represent the molar concentration of sulfide, the solubility product expression for solid silver(I) sulfide ( $\text{Ag}_2\text{S}$ ) is formulated as:
- (a)  $xy$
  - (b)  $x^2y$
  - (c)  $xy^2$
  - (d)  $x^2y^2$
  - (e)  $xy^3$

11. In coordination chemistry, the donor atom of a ligand is
- a Lewis acid.
  - the counter ion
  - the central metal atom/ion.
  - the atom in the ligand that shares an electron pair with the metal.
  - the atom in the ligand that accepts an electron pair from the metal.

12. (Crystal Field Theory) Consider the violet-colored compound,  $[\text{Cr}(\text{OH}_2)_6]\text{Cl}_3$  and the yellow compound,  $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ . Which of the following statements is **TRUE**?



- $\Delta_{\text{oct}}$  for  $[\text{Cr}(\text{OH}_2)_6]^{3+}$  is greater than  $\Delta_{\text{oct}}$  for  $[\text{Cr}(\text{NH}_3)_6]^{3+}$ .
- $\Delta_{\text{oct}}$  for  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  is related directly to the energy of violet light.
- $\Delta_{\text{oct}}$  for  $[\text{Cr}(\text{OH}_2)_6]^{3+}$  is related directly to the energy of violet light.
- A solution of  $[\text{Cr}(\text{OH}_2)_6]\text{Cl}_3$  absorbs light with an approximate wavelength range of 400 - 430 nm.

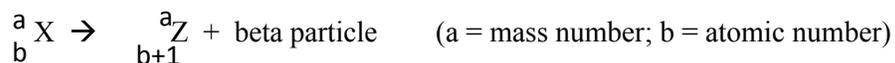
13. What is the oxidation number of the central metal atom in the coordination compound  $[\text{Pt}(\text{NH}_3)_3\text{Cl}]\text{Cl}$ ?

- (a) -1
- (b) 0
- (c) +1
- (d) +2
- (e) +3

14. Which of the following describes what occurs in the fission process?

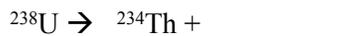
- (a) A heavy nucleus is fragmented into lighter ones.
- (b) A neutron is split into a neutron and proton.
- (c) Two light nuclei are combined into a heavier one.
- (d) A proton is split into three quarks.
- (e) A particle and anti-particle appear in an area of high energy density.

15. Consider the case of a radioactive element X which decays by electron (beta) emission with a half-life of 4 days to a stable nuclide of element Z. Which of the following statements is **CORRECT**?



- (a) After 8 days the sample will consist of one-fourth element Z and three-fourths element X by mass.
- (b) 2.0 g of element X would be required to produce 1.0 g of element Z after 8 days.
- (c) There would be equal masses of X and Z after 8 days.
- (d) After 8 days there would be 0 g of element X present.

16. What is the other product produced in the following nuclear reaction?



- (a) a helium-4 nucleus
- (b) an electron
- (c) a gamma particle
- (d) a positron particle