**Culminating Activity – SCH3U  
Unit E – Solutions and Solubility**

**Student Instructions and Handout**

Pristine Waters

**Part I – Water Testing**

You have been hired as a chemist with the Pristine Waters Company. The Pristine Waters Company is looking for a new source of water that they can then bottle and sell. They would like to find a source of water that requires minimal treatment in order for the water to be safe to sell and drink. PWC has already identified potential water sources and has provided you with samples from these potential sources. As the company’s chemist, your job is to determine whether the water samples you choose to test are safe to drink, and what chemical or physical treatments you would recommend in order for the water to become drinkable. **You must test and report on at least three of the provided samples.** You should consider the following when planning and carrying out your tests:

1. the presence or absence of metals in the water (and the concentration of such metals);
2. the presence or absence of other ions in the water (and the concentration of such ions);
3. the hardness of the water; and
4. the acidity or alkalinity of the water.

(The microbiologists in the lab will be running tests to determine the presence and levels of microorganisms in the water samples so you do not need to propose tests or courses of action to test and treat for microorganisms.)

As PWC wants to the sell their bottled water to consumers in Canada, the water must meet all of Canada’s safe drinking water guidelines. These guidelines can be found at <http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php> and a summary of the chemical and physical parameters can be found at [www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum\_guide-res\_recom/index-eng.php](http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum_guide-res_recom/index-eng.php).

To complete this task successfully you need to:

1. identify the chemical compounds, elements or ions you will be testing your water samples for and prepare a written procedure for each test, including required materials and equipment, for identifying these compounds, elements and ions. ***Your proposed procedure must be approved by your teacher before you proceed with your tests.***
2. Carry out your tests. You **must** follow all laboratory safety procedures. As you carry out your tests, you must make and record your observations, measurements and results. These will become the basis of your report.
3. Write a report to your boss, the president of PWC, detailing the results of your tests. Where appropriate, your report should include balanced chemical equations and concentration calculations. Your report must also include recommendations about which sources of water PWC should or should not use, and the reasons why each particular water sample you tested should or should not be bottled and sold by PWC. If you make a recommendation for a particular water source, you should outline the steps that PWC must take to treat the water before it can be bottled and sold.

**You may work alone or with one or two other chemists in the lab to design and carry out your tests, but each chemist must submit an independently prepared report.**

**Please see the attached rubric for this part of your culminating task.**

**Part II – To bottle or not to bottle**

Despite your assignment above, the Pristine Waters Company may not even go ahead with its water bottling project. There’s been dissent within the company; some people are saying that bottled water tastes better and is safer than tap water, while others are saying that tap water is perfectly good and there’s no need to sell bottled water.

Should PWC proceed with its initial plan to bottle and sell water? What are the benefits and risks of bottled water? What are the benefits and risks of tap water?

Your secondary task is to research these questions and form an opinion about the advantages and disadvantages of both bottled water and tap water. You will then (i) write a persuasive letter to the board of directors of PWC arguing for or against bottled water, or (ii) give a brief (5 -7 minute) persuasive presentation to the board of directors of PWC (who will be represented by your classmates) arguing for or against bottled water.

In your letter or presentation you should:

1. Clearly state your position on the issue of bottle water;
2. Acknowledge and address facts and arguments contrary to your own;
3. Address each of economic, social and environmental benefits and costs.
4. Engage your audience.

**Please see the attached rubric for this part of your culminating task.**

**Teacher Instructions**

This culminating activity provides students numerous opportunities to demonstrate what they have learned and to apply their knowledge of solutions and solubility. Students are asked to test various water samples and make recommendations to their “employer”, the Pristine Waters Company. Students are further given the task of investigating the economic, social and environmental concerns surrounding the issue of bottled drinking water.

**Prior Knowledge:**

* **Terms such as**: solute, solvent, precipitate, limiting reagent, solubility, aqueous solutions, hard water, soft water, stoichiometry
* types of reactions
* writing and balancing equations, including ionic equations
* the concentrations of solutions
* Solubility of ionic compounds
* Testing hard water and soft water
* the ethical use of the Internet for research
* the use, handling, and assembly of scientific apparatus
* the appropriate use of SI units and significant digits in calculations
* percent error calculations
* emergency lab procedures
* planning and carrying out an investigation

**Curriculum Expectations Addressed**:

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| **Curriculum Expectations** | **Task Connections** |
| **A1.2** select appropriate instruments (e.g., a balance, glassware, titration instruments) and materials (e.g., molecular model kits, solutions), and identify appropriate methods, techniques, and procedures, for each inquiry | Creation of testing procedure and  materials list in preliminary report,  performance in the lab |
| **A1.3** identifies and locates a variety of print and electronic sources that enable them to address research topics fully and appropriately |  |
| **A1.4** apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate  Techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection (e.g., wearing safety goggles) | Properly researched and written  safety section in preliminary report,  performance in the lab |
| **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data | Performance in lab, in particular  adaptations to procedure to achieve  conclusive results, observations and  discussion of results in final report |
| **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams | Observations in final report |
| **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge | Observations and discussion in final  report |
| **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models) | Preliminary and final reports,  discussion during lab |
| **E1.2** analyse economic, social, and environmental issues related to the distribution, purification, or use of drinking water (e.g., the impact on the environment of the use of bottled water) [AI, C] | Persuasive letter writing or presentation |
| **E2.1** use appropriate terminology related to aqueous solutions and solubility, including, but not limited to: concentration, solubility, precipitate, ionization, dissociation, pH, dilute, solute, and solvent [C]use a precipitate, ionization, dissociation, pH, dilute, solute, and solvent [C] | analysis section and procedure in  preliminary report |
| **E2.2** solve problems related to the concentration of solutions by performing calculations involving moles, and express the results in various units (e.g., moles per litre, grams per 100 ml, parts per million or parts per billion, mass, volume per cent) [AI, C] | Determining concentration of metals in three water samples |
| **E2.4** conduct an investigation to analyse qualitative and quantitative properties of solutions (e.g., perform a qualitative analysis of ions in a solution) [PR, AI | Lab procedures |
| **E2.5** writes balanced net ionic equations to represent precipitation and neutralization reactions [AI, C] | Analysis section and procedure in  preliminary report |
| **E2.6** use stoichiometry to solve problems involving solutions and solubility [AI] | Analysis section and procedure in  preliminary report, observations  and discussion in final report |
| **E2.8** conduct an investigation to determine the concentrations of pollutants in their local treated drinking water, and compare the results to commonly used guidelines and standards (e.g., provincial and federal standards) [PR, AI] | Preliminary research |
| **E3.4** identify, using a solubility table, the formation of precipitates in aqueous solutions (e.g., the use of Na or aluminum compounds to precipitate and remove metals from water) | Procedure in preliminary report,  observations in final report |

**Accomodations:**

Accommodations that are normally provided in the regular classroom for students with special needs should be provided in the administration of this performance task.

ELL: As an alternative to the persuasive letter or oral presentation, ELL students will be permitted to present their research and arguments for or against bottled water in the form of a PowerPoint or prezi presentation or a video presentation. ELL students will be strategically paired with other students.

IEP: Students with IEPs will have accommodations or modifications made in accordance with their IEP. Some students may have certain expectations eliminated or reduced. Students will be partnered strategically. Some students may be assigned fewer water samples to test or fewer tests to carry out.

Enriched: As indicated above, for the enriched class, students will propose a more difficult analysis of finding heavy metals in the samples. This would require more research and more complicated procedures in the lab. Here are a few resources to support student research:

<http://www.antonine-education.com/jirvine/Chemistry_GCSE/C2b/c2bL16.htm>

<http://www.waterspecialists.biz/html/about_chemical_precipitation.html>

Other enriched students may choose to test more than one water sample or to carry out additional trials or additional or more sophisticated tests.

**Materials (per group):**

* Analytical balance
* Universal pH indicator paper- strips.
* Weighing paper
* Filter paper
* Spatula for weighing
* Washing Bottle
* Two beakers 100 ml
* Cylinder 500 ml
* Two 500-mL Erlenmeyer flasks
* Two 10-mL graduated pipettes with rubber bulb
* Volumetric flask – 50 mL
* Glass road
* Two funnels
* Buchner funnel (if available)
* *other basic equipment will be dictated by the tests and procedures students choose to use*
* *reagent solutions including sodium oxalate and sodium sulphate at appropriate concentrations for students to dilute and use*

**Advance Preparation:**

You will need to find or prepare approximately six separate water samples for the students to test. The solutions should have a range of characteristics and solutes dissolved in them. Possible solutions include:

* Sample 1: An acidic solution (squeeze lemon juice into water)
* Sample 2: A salt solution (add NaCl)
* Sample 3: Toronto tap water (unfiltered)
* Sample 4: Bottled water (preferably not bottled tap water, but actual mineral water)
* Sample 5: Sample of water from British Columbia (water from west coast has unusually soft water stemming from the Mountain Lakes
* Sample 6: Sample of water from Saskatchewan has high concentrations of Ca2+ and Mg2+ which are readily soluble in groundwater, these exceed 200ppm (hardwater)

**Note:**

* The samples you use are arbitrary. The point of this exercise is for students to gain an understanding of chemical reactions having limiting reactants, finding the mass and concentrations of precipitated compounds.
* Each group will receive 3 different samples, ensuring that no two groups have the same set of samples.
* Students will compare their three given examples by precipitating out metals (Ca2+ and Mg2+), by using Sodium Oxalate (McGraw-Hill text, page 363). Alternatively students might choose to precipitate Ca ions only using sodium sulphate. Students may have other proposed methods that should be assessed on a case-by-case basis.
* Students will then calculate concentration of calcium and/or magnesium in the sample.
* Decide by comparing to standard concentrations, if their sample is hard or soft
* They will then test the pH of each water sample.

**Plan of Culminating Activities (**Three periods – **225 min)**

**Depending on class size, teacher can divide up the class into groups of 2 – 4, each group receiving 3 out of 6 samples to test.**

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| Activities | Activity sequencing | Teaching & Learning Strategies | Assessment  **For Learning**  **Of Learning** | Expectations Addressed |
| **Introduction to Culminating Activity**  (**75 min** Day 1)  Students will have time between day 1 and day 2 of culminating to solidify their first part of the activity | **1.** Task Introduction  **Research: (done in library using text and internet)**  **2.** Analysing and Choosing chemical compounds for investigation and develop a chemical equation for the analysis.  **3.** Designing the experiment to solve the task   1. Creating Proposal for experiment:   What should be included:  Procedures for:  a) pH using indicator paper (or titration)  b) Precipitate metals (using sodium oxalate or sodium sulphate)  c) Testing water hardness by comparing to standards.  **B.** Required Safety Measures  **C.** Required Equipment and Materials | *Brainstorm in groups*  *(Teacher to provide example problems and their solutions)*  *Inquiry*  *Cooperative learning*  *Provide students with checklist of required components*  Teacher to support students through the inquiry process of safe solutes to use for experiment | **For. Initial:** Create plan of action: **T/I (Teacher to provide students with feedback on original plan)**  **Of.** Final proposal handed in date to be determined, **KU, TI, C, A – see rubric**  **S.** Students Performance list, **K/U, A**  **S.** Checklist, | E1.1 E2.1, E2.2, E2.4, E2.5, E2.6, E2.7,E3.2E3.4 |
| **Culminating Day 2**  **In the Lab** | **Students to carry out their tests which may include:**   * **Solution preparations** * **Lab procedure** * **Analysis of results** * **Comparing to standards** | (teacher to include worksheet with questions to facilitate proper analysis of results)  Problem solving,  Investigation | **Of:** teacher checklist – evaluating proper lab procedures including use of equipment and safety measures. | E1.1, |
| **Culminating Day 3**  Group discussions | Finding answer to problems, using textbook and previous research:   * Discuss with group members results of all three samples * Decide using research which sample would be best for company * Prepare report individually to your boss discussing which sample would be best and back up your reasoning using your analysis of the chemical reactions. | *problem solving, cooperative learning,*  *group discussion* | **Assessment of: see** rubric **K/U, C, A** | A1.11,E1.1, E2.1 |

**Extension:**

* **Provide students with time to complete part II**
* **Handout rubric and discuss expectations**
* **This is to be done as an individual study**

**Resources:**

Texts:

Jenkins, F. et al (2002). Chemistry 11. (Toronto, ON: Nelson Thomson Learning).

Mustoe, F. et al (2002). Chemistry 11. (Whitby, ON: McGraw-Hill Ryerson).

**Websites:**

<http://www.antonine-education.com/jirvine/Chemistry_GCSE/C2b/c2bL16.htm>

<http://www.waterspecialists.biz/html/about_chemical_precipitation.html>

<http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php>

[www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum\_guide-res\_recom/index-eng.php](http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum_guide-res_recom/index-eng.php).

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| **Part I: Water Testing and Report Rubric** | | | | | |
| **Categories** | **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Weight** |
| **Knowledge and Understanding – the student:**   * Chooses an appropriate range of tests to conduct * Effectively explains the tests he or she has chosen   (E3.4, E3.2, E2.1) | * Chooses a limited range of tests to conduct * Explains the chosen tests with limited effectiveness | * Chooses an adequate range of tests to conduct * Explains the chosen tests with some effectiveness | * Chooses an appropriate range of tests to conduct * Explains the chosen tests with considerable effectiveness | * Chooses an exceptional range of tests to conduct * Explains the chosen tests with high degree of effectiveness | / 30 |
| **Thinking and Investigation – the student:**   * Accurately describes chemical reactions through balanced chemical equations * Accurately carries out calculations * Effectively interprets the results of tests   (E2.2, E2.4, E2.5, E2.6) | * Describes chemical reactions through balanced chemical equations with limited accuracy * Carries out calculations with limited accuracy * Interprets results of tests with limited effectiveness | * Describes chemical reactions through balanced chemical equations with some accuracy * Carries out calculations with some accuracy * Interprets results of tests with some effectiveness | * Describes chemical reactions through balanced chemical equations with considerable accuracy * Carries out calculations with considerable accuracy * Interprets results of tests with considerable effectiveness | * Describes chemical reactions through balanced chemical equations with high degree of accuracy * Carries out calculations with high degree of accuracy * Interprets results of tests with high degree of effectiveness | / 30 |
| **Application – the student:**   * Effectively explains and provides evidence for his or her recommendations   (E1.1) | * Explains recommendations with limited effectiveness * No or little evidence is provided to support recommendations | * Explains recommendations with some effectiveness * Some evidence is provided to support recommendations | * Explains recommendations with considerable effectiveness * Considerable evidence is provided to support recommendations | * Explains recommendations with a high degree of effectiveness * Abundant evidence is provided to support recommendations | / 10 |
| **Communication – the student:**   * Clearly communicates results of tests in table or summary format * Accurately uses scientific terminology and vocabulary   (E2.1, A1.11) | * Communicates results of tests with limited clarity * Uses scientific terminology and vocabulary with limited accuracy | * Communicates results of tests with some clarity; * Uses scientific terminology and vocabulary with some accuracy | * Communicates results of tests with considerable clarity; * Uses scientific terminology and vocabulary with considerable accuracy | * Communicates results of tests with high degree of clarity; * Uses scientific terminology and vocabulary with exceptional accuracy | / 10 |

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| **Part II: Letter / Presentation Rubric** | | | | | |
| **Categories** | **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Weight** |
| **Persuasiveness**   * Clearly articulates his or her opinion or position * Persuasively presents his or her arguments * Acknowledges facts and rebuts arguments contrary to his or her position | * articulates his or her opinion or position with limited clarity * Presents his or her arguments with limited persuasiveness * Fails to acknowledge facts and rebut arguments contrary to his or her position | * articulates his or her opinion or position with some clarity * Presents his or her arguments with some persuasiveness * acknowledges facts and rebut arguments contrary to his or her position in a limited manner | * articulates his or her opinion or position with considerable clarity * Presents his or her arguments with considerable persuasiveness * acknowledges facts and rebut arguments contrary to his or her position in an adequate manner | * articulates his or her opinion or position with exceptional clarity * Presents his or her arguments with exceptional persuasiveness * acknowledges facts and rebut arguments contrary to his or her position in an thorough manner | / 10 |
| **Research:**   * Presents evidence of conducting thorough research * Uses credible sources * Addresses economic, social and environmental concerns | * Presents limited evidence of conducting research * Few or no sources used are credible * Fails to addresses each of economic, social and environmental concerns | * Presents some evidence of conducting research * Some sources used are credible * Addresses some of economic, social and environmental concerns | * Presents considerable evidence of conducting research * Most sources used are credible * Addresses each of economic, social and environmental concerns | * Presents exceptional evidence of conducting research * All sources used are credible * Thoroughly addresses each of economic, social and environmental concerns | / 10 |
| **Presentation**   * Information is presented in a clear and logical manner * Presentation is engaging | * Information is presented in a unclear or illogical manner * Presentation/letter is minimally engaging | * Information is presented in a somewhat clear and logical manner * Presentation/Letter is somewhat engaging | * Information is presented in a mostly clear and logical manner * Presentation/letter is considerably engaging | * Information is presented in a exceptionally clear and logical manner * Presentation/letter is exceptionally engaging | / 5 |

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| **Part I: Water Testing and Report Rubric** | | | | | |
| **Categories** | **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Weight** |
| **Knowledge and Understanding – the student:**   * Chooses an appropriate range of tests to conduct * Effectively explains the tests he or she has chosen   (E3.4, E3.2, E2.1) | * Chooses a limited range of tests to conduct * Explains the chosen tests with limited effectiveness | * Chooses an adequate range of tests to conduct * Explains the chosen tests with some effectiveness | * Chooses an appropriate range of tests to conduct * Explains the chosen tests with considerable effectiveness | * Chooses an exceptional range of tests to conduct * Explains the chosen tests with high degree of effectiveness | / 25 |
| **Thinking and Investigation – the student:**   * Accurately describes chemical reactions through balanced chemical equations * Accurately carries out calculations * Effectively interprets the results of tests   (E2.2, E2.4, E2.5, E2.6) | * Describes chemical reactions through balanced chemical equations with limited accuracy * Carries out calculations with limited accuracy * Interprets results of tests with limited effectiveness | * Describes chemical reactions through balanced chemical equations with some accuracy * Carries out calculations with some accuracy * Interprets results of tests with some effectiveness | * Describes chemical reactions through balanced chemical equations with considerable accuracy * Carries out calculations with considerable accuracy * Interprets results of tests with considerable effectiveness | * Describes chemical reactions through balanced chemical equations with high degree of accuracy * Carries out calculations with high degree of accuracy * Interprets results of tests with high degree of effectiveness | / 25 |
| **Application – the student:**   * Effectively explains and provides evidence for his or her recommendations   (E1.1) | * Explains recommendations with limited effectiveness * No or little evidence is provided to support recommendations | * Explains recommendations with some effectiveness * Some evidence is provided to support recommendations | * Explains recommendations with considerable effectiveness * Considerable evidence is provided to support recommendations | * Explains recommendations with a high degree of effectiveness * Abundant evidence is provided to support recommendations | / 15 |
| **Communication – the student:**   * Clearly communicates results of tests in table or summary format * Accurately uses scientific terminology and vocabulary   (E2.1, A1.11) | * Communicates results of tests with limited clarity * Uses scientific terminology and vocabulary with limited accuracy | * Communicates results of tests with some clarity; * Uses scientific terminology and vocabulary with some accuracy | * Communicates results of tests with considerable clarity; * Uses scientific terminology and vocabulary with considerable accuracy | * Communicates results of tests with high degree of clarity; * Uses scientific terminology and vocabulary with exceptional accuracy | / 15 |

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| **Part II: Debate / Letter / Presentation Rubric** | | | | | |
| **Categories** | **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Weight** |
| **Persuasiveness**   * Clearly articulates his or her opinion or position * Persuasively presents his or her arguments * Acknowledges facts and rebuts arguments contrary to his or her position | * articulates his or her opinion or position with limited clarity * Presents his or her arguments with limited persuasiveness * Fails to acknowledge facts and rebut arguments contrary to his or her position | * articulates his or her opinion or position with some clarity * Presents his or her arguments with some persuasiveness * acknowledges facts and rebut arguments contrary to his or her position in a limited manner | * articulates his or her opinion or position with considerable clarity * Presents his or her arguments with considerable persuasiveness * acknowledges facts and rebut arguments contrary to his or her position in an adequate manner | * articulates his or her opinion or position with exceptional clarity * Presents his or her arguments with exceptional persuasiveness * acknowledges facts and rebut arguments contrary to his or her position in an thorough manner | / 20 |
| **Research:**   * Presents evidence of conducting thorough research * Uses credible sources * Addresses economic, social and environmental concerns | * Presents limited evidence of conducting research * Few or no sources used are credible * Fails to addresses each of economic, social and environmental concerns | * Presents some evidence of conducting research * Some sources used are credible * Addresses some of economic, social and environmental concerns | * Presents considerable evidence of conducting research * Most sources used are credible * Addresses each of economic, social and environmental concerns | * Presents exceptional evidence of conducting research * All sources used are credible * Thoroughly addresses each of economic, social and environmental concerns | / 20 |
| **Presentation**   * Information is presented in a clear and logical manner * Presentation is engaging | * Information is presented in a unclear or illogical manner * Presentation is minimally engaging | * Information is presented in a somewhat clear and logical manner * Presentation is somewhat engaging | * Information is presented in a mostly clear and logical manner * Presentation is considerably engaging | * Information is presented in a exceptionally clear and logical manner * Presentation is exceptionally engaging | / 10 |

**Laboratory Conduct**

**Lab Conduct Marking Scheme** [T/I] (to be used by teacher through observation on laboratory days)

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| **Criteria** | **Level 4** | **Level 3** | **Level 2** | **Level 1** | **Level 1 R** |
| **Set up** | Well-organized, quick  set-up with no  assistance; correct  selection and use of  equipment and  materials | Well-organized, quick  set-up; correct  selection and use of  equipment and  materials. | Mostly correct  selection and use of  equipment and  materials; some  assistance needed | Several errors in  selection and use of  equipment and  materials; some  assistance needed. | Major errors in  selection and use of  equipment and  materials; frequent  assistance needed. |
| **Safety** | Proper safety  procedures are  consistently used;  frequently thinks  ahead to ensure safety | Proper safety  procedures are  consistently used | Proper safety  procedures are  generally used; needs  to be reminded once  during the lab. | Proper safety  procedures are often  missed; needs to be  reminded more than  once during the lab. | Proper safety  procedures are  consistently missed;  needs to be reminded  often during the lab |
| **Focus** | Stays on task  throughout the lab;  follows procedure and  records adaptations as  necessary. | Stays on task for the  majority of the lab;  follows procedure and  records adaptations as  necessary. | Occasionally loses  focus during the lab;  follows procedure but  does not always record  adaptations. | Often loses focus  during the lab; follows  procedure but does not  record adaptations | Has to be reminded to  stay on task; does not  follow procedure |
| **Clean up** | Proper clean up  procedures are  consistently used;  frequently thinks  ahead to ensure safety | Proper clean up  procedures are  consistently used. | Proper clean up  procedures are  generally used; needs  to be reminded of  proper technique | Proper clean up  procedures are often  missed; needs to be  reminded more than  once of proper  technique. | Proper clean up  procedures are  consistently missed;  needs to be reminded  often of proper  technique. |