**DESIGN-A-LAB 1: HEAT OF REACTION**

You goals it design a lab demonstration to measure the heat of reaction. You will be required to submit the following components:

* Introduction including:
	+ Objective statement with balanced chemical reaction
	+ Relevance of this reaction and safety concerns associated with both reactants and products
	+ Hypothesis statement based on Hess’s law calculation including vocabulary of exothermic or endothermic
* Methods
	+ Written step-by-step OR paragraph form OR flow chart
	+ BE SURE YOUR QUANTITIES CONSIDER WHICH REACTANT MAY BE LIMITING
	+ Needs to be written clearly and concisely \*\*feel free to use published methods, as long as you paraphrase and cite your references\*\*☺
* Discussion
	+ Includes the result, percent error, and a discussion of possible experimental errors
* Appendix
	+ Includes three calculations: Hess’s Law, Heat of Reaction, and Percent Error

Scoring

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Outcome  | Descriptors  | Score YOU  | Score  | Score  | Score  |
| Research  | The reaction of study was interesting and relevant. The safety concerns were explored thoroughly. Reference values were identified from reliable, research-based sources. References were all cited in ACS format in text.  |  |  |  |  |
| Experimental Design | All major variables were controlled (think: calorimeter – how well is my reaction insulated?). The protocol is written clearly and concisely. Appropriate instruments are selected.  |  |  |  |  |
| Data Collection and Calculations | Data was collected accurately and precisely. Raw data was used properly in calculations of heat of reaction and percent error. Significant digits were considered.  |  |  |  |  |
| Team Work | Group works cooperatively and collaboratively. Tasks are delegated so each member has a specific role. Disagreements are resolved democratically.  |  |  |  |  |
| Written Report  | The submission is well-written and organized. It contains little to no errors in grammar, appropriate formatting, and uses scientific vocabulary.  |  |  |  |  |

Scoring Scale

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Novice (1)0-49% | Novice + (2)50-59% | Apprentice (3) 60-69% | Apprentice + (4)70%-79% | Expert- (5)80-94% | Expert+ (6)95-100%  |
| I am only beginning to do this and most always need help, intervention from my teacher or my peers. Time for extra help. | I occasionally do this, but am still in learning stages. I usually need intervention or guidance from teacher or my peers.  | I do this some of the time, but often need teacher assistance and/or guidance. Extra help is needed.  | I do this appropriately MOST of the time, but sometimes I need assistance and/or guidance. | I do this satisfactorily MOST of the time, and I am very close to being a role model who could teach others.  | I do this exceptionally well ALL the time. I am a role model to my peers and could effectively teach others.  |

Heat of Reaction: Sodium bicarbonate and acetic acid

Chemistry 12-2

Ms. Wilson

Sally Slacker, Oliver Overachiever and Patty Passive

**Introduction**

 The objective of this lab is to determine experimentally the heat of reaction for the reaction of acetic acid and sodium bicarbonate.

C2H4O2 (aq) + NaHCO3 (s) 🡪 NaC2H3O2 (aq) + H2O (l) + CO2 (g)  ∆H° = 45.7 kJ

This reaction is relevant in the culinary industry, as these chemicals are commonly known as vinegar and baking soda. Sodium bicarbonate is a weak base and has several applications in household products including as an odor neutralizer and toothpaste additive.1 There are no safety concerns of working with sodium bicarbonate and acetic acid, as long as it is used in low concentrations. Solutions with high concentrations of acetic acid can be corrosive to the skin.2 Personal protective equipment should also be warn as a precaution.

 Based on Hess’s law, the heat of reaction for the endothermic reaction of acetic acid and sodium bicarbonate at standard conditions is 45.7 kJ, Appendix A.3

**Methods**

 A coffee cup calorimeter is set up using two 16-ounze insulated cups placed one inside the other. 200.0 mL of 5% (v/v) acetic acid is added to the cup and an insulated lid is placed on the top and sealed. A thermometer is placed through the hole in the lid and secured vertically using a clamp stand. The initial temperature is recorded. A glass stirrer is also placed through a second hole in the lid.

The lid is removed and 10.0 g of sodium bicarbonate is added to the cup. Sodium bicarbonate is the limiting reagent in this experiment. The lid is replaced quickly. The reaction is stirred from 2 minutes. After 2 minutes, the final temperature is recorded.

**Discussion**

 The experimental heat of the reaction was calculated to be 2508 J, Appendix B. As 10.0 g of sodium bicarbonate was added in this experiment, the theoretical value is calculated to be 5440 J, Appendix C. Therefore, the percent error is 54.0%. There are several reasons to explain the discrepancy between theoretical and experimental values. The sodium bicarbonate and acetic acid may not have reacted to competition. The insulation of the coffee cup calorimeter was not perfect. Some heat may have been lost or gained form the surroundings of the cup. There may have also been heat lost or gained between the times the solid was added and when the lid was replaced.

**References**

1Putt, M.; Milleman, K.; Ghassemi, A.; Vorwerk, L.; Hooper, W.; Soparkar, P.; Winston, A.; Proskin, H. Enhancement of plaque removal efficacy by tooth brushing with baking soda dentifrices: results of five clinical studies. *J. Clin. Dent.* [Online] **2008**, 19, 1-4. ttps://www.researchgate.net/profile/Mark\_Putt/publication/24193167\_Enhancement\_of\_plaque\_removal\_efficacy\_by\_tooth\_brushing\_with\_baking\_soda\_dentifrices\_Results\_of\_five\_clinical\_studies/links/555b610608ae6aea0816bf4d.pdf

*2Acetic Acid*; SDS [Online]; AquaPhoenix Scientific: Hanover, PA, June 1, 2015. https://beta-static.fishersci.com/content/dam/fishersci/en\_US/documents/programs/education/regulatory-documents/sds/chemicals/chemicals-a/S25118.pdf (accessed Feb 17, 2020).

3CRC Handbook of Chemistry and Physics, 88th ed.; Lide, D.R., Ed.; CRC Press: Boca Raton, FL, 2007.

**Appendix**

1. Calculation of Theoretical Heat of Reaction

$$∆H^{o}=sum of ∆H\_{f}^{0}\left(products\right)- sum of ∆H\_{f}^{o}(reactants)$$

1. Calculation of Experimental Heat of Reaction

$$∆H\_{reaction}= -q\_{surroundings}= -m x C x ∆T$$

1. Calculation of Percent Error

$$Percent error= \frac{|experimental-theoretical|}{|theoretical|} x 100\%$$

Example Scoring

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outcome  | Descriptors  | Score (1 to 6) YOU: Oliver Overachiever | Score (1 to 6)Sally Slacker | Score (1 to 6)Patty Passive |
| Research  | The reaction of study was interesting and relevant. The safety concerns were explored thoroughly. Reference values were identified from reliable, research-based sources. References were all cited in ACS format in text.  | 6 | Did not observe- Sally absent.  | 2 – Patty had trouble researching |
| Experimental Design | All major variables were controlled (think: calorimeter – how well is my reaction insulated?). The protocol is written clearly and concisely. Appropriate instruments are selected.  | 6 | 1 – did not help at all. Watched youtube instead.  | 3 |
| Data Collection and Calculations | Data was collected accurately and precisely. Raw data was used properly in calculations of heat of reaction and percent error. Significant digits were considered.  | 5 – I’m not so good with sig digs | Did not observe – Sally was absent  | 3 |
| Team Work | Group works cooperatively and collaboratively. Tasks are delegated so each member has a specific role. Disagreements are resolved democratically.  | 5 – Sally was a hindrance to the group. | 1 – Sally refused to help. | 2- Patty was present, but did not complete the task assigned.  |
| Written Report  | The submission is well-written and organized. It contains little to no errors in grammar, appropriate formatting, and uses scientific vocabulary. Exemplary!  | 6 – I did most myself  | Did not observe – Sally did not help  | 4- Patty helped with experimental design and experiment.  |