**Chem Honors WKS: Accuracy, Precision & Significant Figures in Measurements**

**NAME** Answer Key
**Period** _____ **Date** _____

1. What is accuracy?
   How close a measurement is to the actual or accepted value.

2. What is precision for a group of measurements?
   How close together a group of measurements is (or how close one is to the others)

3. What is meant by *random error*? How can you reduce random error in an experiment?
   It is the inconsistency in measurement from one measurement or person to the next. Its effects are removed by averaging measurements, and it can be reduced by using the most precise device that has enough capacity (with the closest/smallest divisions)

4. What is meant by *systematic error*? How can you reduce systematic error in an experiment?
   It is error due to bad design or misreading equipment. It can be reduced by fixing (calibrating) equipment or improving the experimental procedure.

5. Two students measured the densities of 3 separate samples of sucrose (accepted D = 1.59 g/cm$^3$) and obtained the following results. Find the average density for each student, then use that average to determine each student's % error. Which student was most accurate? Which student was most precise? Explain your choices.

$$\%\text{Error (B)} = \frac{\left|1.51\ \text{g/cm}^3 - 1.59\ \text{g/cm}^3\right|}{1.59\ \text{g/cm}^3} \times 100\% = 5\%$$

$$\%\text{Error (C)} = \frac{\left|1.70\ \text{g/cm}^3 - 1.59\ \text{g/cm}^3\right|}{1.59\ \text{g/cm}^3} \times 100\% = 6.9\%$$

| Density Data of Sucrose | | |
|---|---|---|
| | Student B | Student C |
| Trial | Density (g/cm$^3$) | Density (g/cm$^3$) |
| 1 | 1.40 | 1.70 |
| 2 | 1.68 | 1.69 |
| 3 | 1.45 | 1.71 |
| Avg | 1.51 | 1.70 |

Student B was more accurate because she had a smaller % Error in her average.
Student C was more precise because he had a smaller spread in his data.

6. A piece of wood has a labeled length of 76.49 cm. You measure its length three times and record the following data: 76.48 cm, 76.47 cm, and 76.59 cm. How many significant figures do these measurements have?
   Four

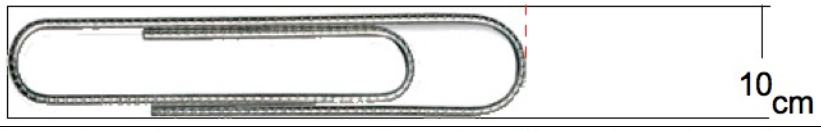
7. Calculate the percent error for each measurement in problem 6 to the correct number of sig figs.

$$\%\ \text{error} = \frac{\left|76.48\ \text{cm} - 76.49\ \text{cm}\right|}{76.49\ \text{cm}} \times 100\% = 0.01\%\ ;\ 0.03\%;\ 0.13\%$$

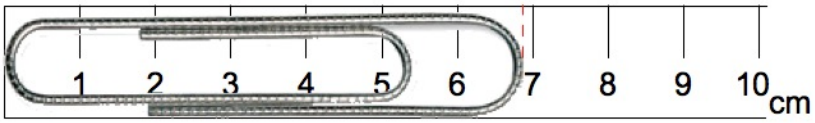
8. Are the measurements in problem 6 accurate? Are they precise? Explain your answers.
   Yes, they are accurate (especially the first two) since they are close to the accepted value, although the third value is less accurate. The first two measurements are precise, the third less precise (especially for measurements taken to the hundredth of a cm).

9. Which of these measurements was made with the most precise measuring device: 8.1956 m, 89.20 m, or 8.196 m? Explain your answer.
   8.1956 m because it has the greatest number of significant figures.

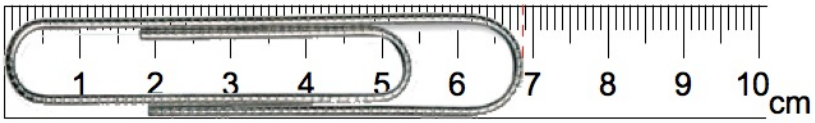
10. On the rulers below, measure the length of the paper clip, in cm. The measurements will NOT be identical. You must read to the calibration markings then estimate the next decimal place as the final digit. Cover up the ruler(s) below the one you are using to prevent being influenced by them. Indicate the precision as ±1 in the estimated (least significant) digit.




length: 7 ± 1 cm — 1 sig. fig(s).




length: 6.9 ± 0.1 cm — 2 sig. fig(s).



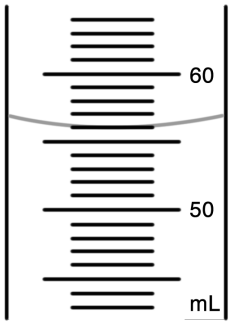

length: 6.87 ± 0.01 cm — 3 sig. fig(s).

a. Why were the measurements different?
They represent different levels of precision in the measurement.

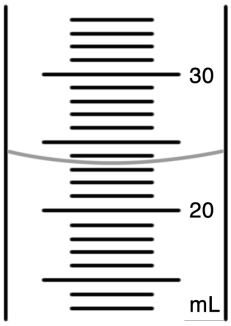
b. Which measurement required the greatest amount of estimation? Which has the most precision? Explain.
The first requires the most estimation since it has the fewest divisions and largest gap between markings; the last has the most precision since it has the most (and smallest) divisions.

c. How did you indicate the differences in the precision in your measurements?
By increasing the number of digits as the precision of the measurement increases.

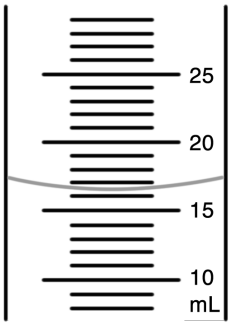
11. **Measuring Volume:** Determine the volume of $H_2O$ in the following graduated cylinders, using the correct sig figs. Remember to read at the bottom of the meniscus. Indicate the precision as in #10.



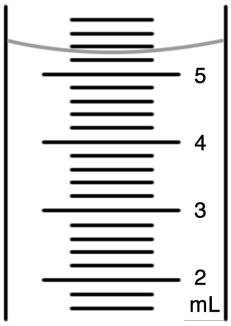

a. 56.0±0.1 mL



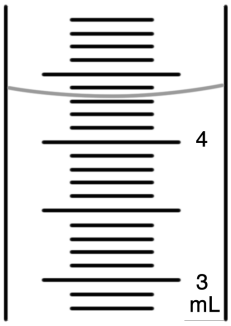

b. 23.5±0.1 mL




c. 16.5±0.1 mL




d. 5.3±0.1 mL




e. 4.33±0.01 mL

12. Identify the number of significant figures (you do not need units on sig figs):

| | | | |
|---|---|---|---|
| a. 3.0800 kg | 5 (precision 0s at end) | b. 0.00418 m | 3 (magnitude 0s at start) |
| c. $7.09 \times 10^{-5}$ L | 3 (included 0s) | d. 91,600 miles | 3 (magnitude 0s at end) |
| e. 0.003005 g | 4 (magnitude 0s at start) | f. 38 books | ∞ (count) |
| g. $3.200 \times 10^{9}$ s | 4 (precision 0s at end) | h. 250 °C | 2 (magnitude 0 at end) |
| i. 780,000,000 km | 2 (magnitude 0s at end) | j. 20 years in one score | ∞ (defined) |
| k. 0.0101 mL | 3 (magnitude 0s at start) | l. 0.00800 cm | 3 (precision 0s at end) |
| m. 20,700 inches | 3 (magnitude 0s at end) | n. $5.0002 \times 10^{8}$ J | 5 (included 0s) |