Activity 7: Measurements of Length, Mass, Temperature, and Volume

Introduction

In Chemistry and in everyday life, you constantly use various types of measurements. Measurements have two parts, just like your name: there’s a number and a unit. In this Activity, you’ll become more familiar with making measurements, and with converting from one unit to another.

For many activities, you will be told to find (measure) some value “to the nearest 0.1 unit.” This means you should record your measurement to one decimal place, such as 167.2 cm or 25.8 g.

You can do Parts 1, 2, 3, 4, or 5 in any order—in fact, since we have limited equipment for some of these, not everyone can do them at the same time.

It will be very helpful to have a calculator when you work through the parts of this activity.

Remember to include the units in all measurements.

Don’t forget that you can learn more about SI units in Chapter 3 of your textbook.

Part 1 – Length

Length is important in everyday life, but not as important in chemistry. Most objects studied in chemistry are sub-microscopic, such as molecules and atoms, or occur as liquids or gases. But you may want to start with this part because you are already familiar with what length means. Use a meter stick or ruler to make these measurements.

Problem Set A

1. Find your height to the nearest 0.1 cm ________________________________
   Convert this into ______ m _________ cm

2. Find the circumference of your head to the nearest 0.1 cm ________________

3. Find the distance from your elbow to the end of your middle finger, to the nearest 0.1 cm ________________
   (If time permits, we will learn to make graphs using your class data.)

Problem Set B

4. Find the length of one floor tile to the nearest 0.1 cm _______________________
   What would be the length of 10 floor tiles? ________________________________
   Measure 10 tiles to find out if your calculation was right. _____ yes _____ no

5. If a room is 3.4 m high, how many centimeters is this? _______________________

6. If a river is 5.1 km wide, how many meters is this? _________________________

7. If a basketball player is 210 cm tall, how much taller is he than you are? ________
Part 2 – Mass

“Mass” in science means “how much there is of something.” You measure mass with a balance scale (or simply a “scale.”) In science classes, you may use a “pan” balance or “electronic” scale.

Often, you use the term “weight” to mean the same thing. But to a scientist, there is a difference because weight really measures a force that changes depending on how high above the Earth a measurement is made. You actually “lose” weight when you walk upstairs or rise in an airplane, and “gain” it back when you go back down.

Before making a measurement with a balance scale, it is important to calibrate the instrument. This means checking its accuracy by placing an object with a known mass on the scale, and making adjustments if necessary.

Follow your teacher’s directions about how to calibrate your scale.

Problem Set C

8. Use the electronic scale to find the mass of the objects provided, and record them to the nearest 0.1 g.

- paper clip ___________________________________________
- calcite crystal _________________________________________
- 100 mL beaker _________________________________________
- rubber stopper _________________________________________
- rock sample (record its letter) ____________________________

9. a) If a student weighed (has a mass of) 74.2 kg, how many g is this?

___________________________
Write this in scientific notation _____________ x 10

b) If a sample of NaCl has a mass of 105.5 g, how many kg is this?

___________________________
Write this in scientific notation _____________ x 10

Part 3 – Temperature

In the United States and a few other countries, we still use for daily purposes the Fahrenheit temperature scale. But everywhere else in the world, and for all Science measurements, we use the Celsius or centigrade scale. In this system, the temperature at which water freezes/melts is 0°, and the boiling point is 100°.

Problem Set D

10. Use a thermometer to measure the temperature of

a) boiling water ________________________ (Note: Try not to touch the bottom of the pot.)

b) an ice/water mixture ________________________ (Same Note as above.)

c) “room temperature” ________________________

11. What is “normal body temperature” on the centigrade scale? ___________________
Part 4 – Liquid Volume

Many times in chemistry you will be asked to measure a certain volume of a liquid solution. The basic SI unit is the liter (symbolized as L), or for smaller amounts, the milliliter (mL). Depending on what you are trying to measure, you would use a graduated beaker, graduated cylinder, or pipette.

One of the major problems with beakers and cylinders is that the marks are often far apart, so it is difficult to know the exact level. Most measurements made with these containers are really estimates. With cylinders, another problem is that the top surface usually shows a curved shape. This is caused by water adhering (sticking) to the glass or plastic surface. The correct value is read at the bottom of the curve.

Problem Set E

12. Practice using a graduated beaker to measure the following volumes, and then put a check when you have done this.

_____ 85 mL
_____ 125 mL
_____ 210 mL

13. Practice using a graduated cylinder to measure the following volumes, and then put a check when you have done this.

_____ 7.5 mL
_____ 16 mL
_____ 76 mL

14. A pipette allows a person to make very careful measurements of liquids. This is very important in many chemical activities.

Practice using the available pipettes to measure small amounts of water, and describe what you did.

15. a) How many L are 454.6 mL? ________________
   Write this in scientific notation _____________ x 10

b) How many mL are 2.2 L? ________________
   Write this in scientific notation _____________ x 10
Part 5 – Solid/Gas Volume

Solids are sometimes measured in cubic units. In Chemistry, we usually use small amounts and deal with cubic centimeters (symbolized as \(\text{cm}^3\) or \(\text{cc}\)). In other situations, you may find volumes measured in cubic meters or, for very large measurements about our Planet Earth, cubic kilometers.

Measurements of gases are sometimes measured in cubic units and in liters or milliliters are other times. You will learn more about which to use when we study more about gases later in the year.

Problem Set F

16. Use the ruler to measure and record, to the nearest 0.1 cm, the box’s

   length (longest side) ____________________
   width (middle side) ____________________
   thickness (smallest side) ______________

To find the volume of a “regularly-shaped” solid, you multiply the
   (length) x (width) x (thickness) = volume
   Find the volume (in \(\text{cm}^3\)): _____________________________

17. To find the volume of an “irregularly-shaped” volume, such as a rock, you can use the water-displacement method. When you submerge something in water in a container, the water level changes by an amount equal to the volume of the object. So if you subtract the original level from the final level, you have the volume of the object.

   Note: 1 mL (liquid volume) = 1 \(\text{cm}^3\) (solid volume)

   Use the water-displacement method with the graduated cylinders or beakers to find the volumes of the same objects you used for the mass measurements.
   Record these to the nearest 1 \(\text{cm}^3\).

   calcite crystal ____________________________
   100 mL beaker ____________________________
   rubber stopper ____________________________
   rock sample (give letter) _________________

Comment about any problems you may have had trying to use the water-displacement method:
Questions
1. Which type of measurement you made probably has the least accuracy? Why?

2. Which measurements are probably most accurate? Why?

3. Describe what you need to do to calibrate a balance scale.

4. Suppose a student measures the volume of a rock with the water-displacement method as 235 cm³, but the rock really has a volume of 248 cm³.
   a. Show how to calculate the error.

   b. Show how to calculate the percent error.

5. Give five examples of how you use measurements in your everyday life.
Notes

Applicable Standard(s): NJCCCS 5.1A, B, and C; 5.3

Materials needed per group:
- meter stick
- string
- balance scale
- paper clip
- calcite crystal
- rock
- rubber scale
- 100-, 150-, and 250-ml graduated beakers
- 10-, 25, and 100-mL graduate cylinders
- thermometer
- pipette and pipettor
- water
- a tray
- calculator