Lab #3
Tools for Scientific Inquiry &
The Metric System

I. Exercise 1 – Scientific Notation

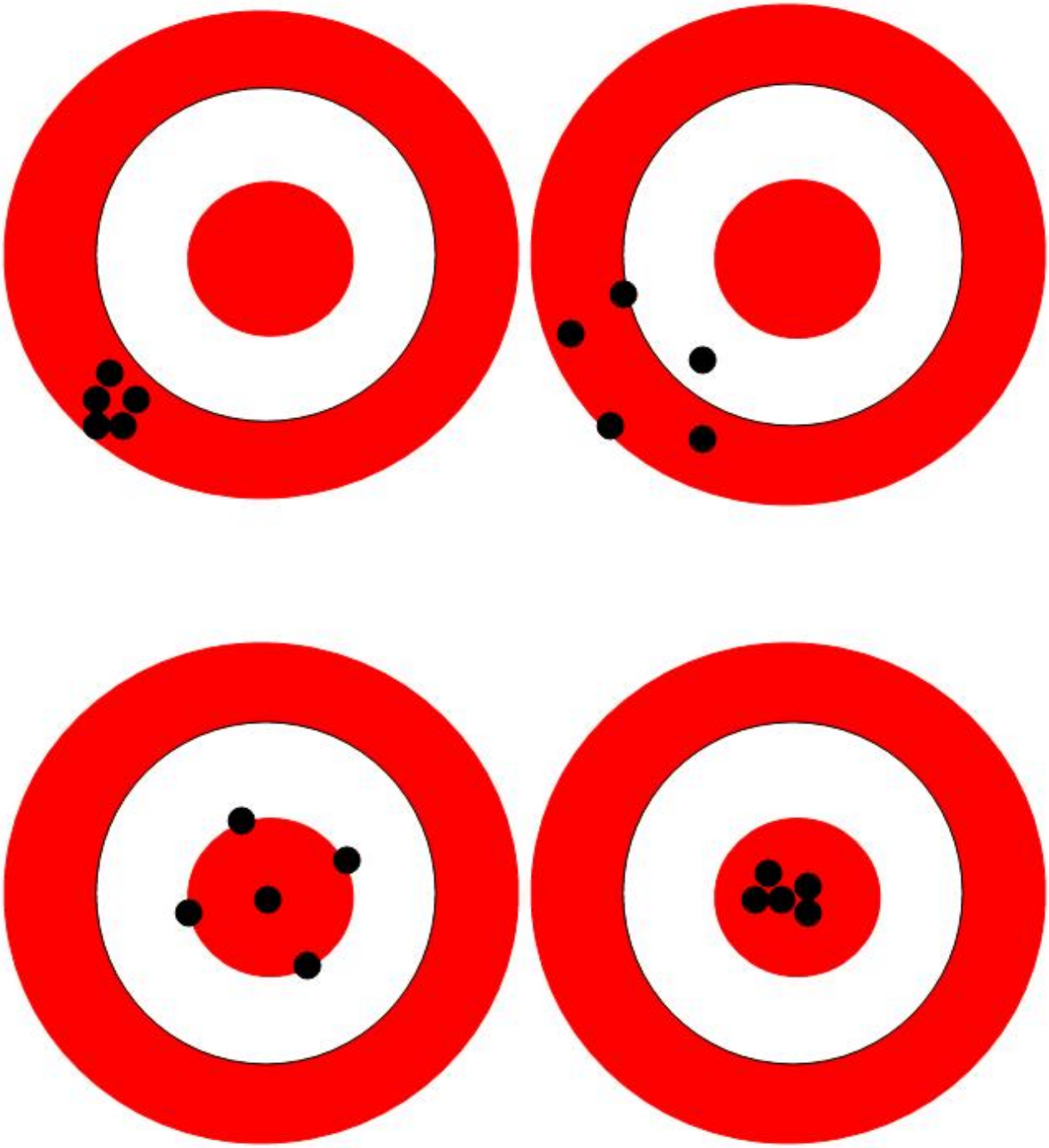
A. Scientific notation is capable of easily handling very small and very large numbers
   1. A x 10^n
      a) where A is a number between 1 and 10
      b) and n is the number of decimal places that the decimal moves from the starting point
         i. a negative *n* means the decimal point moves to the left
         ii. a positive *n* means the decimal point moves to the right
   2. Examples:
      a) $1.2 \times 10^5 \rightarrow 120{,}000$
      b) $4.0 \times 10^{12} \rightarrow 4{,}000{,}000{,}000{,}000$
      c) $5.74 \times 10^{-6} \rightarrow 0.00000574$
      d) $1.0 \times 10^{-1} \rightarrow 0.1$
   3. Multiplication
      a) The numbers (A's) are multiplied
      b) The *n*'s are added together
      c) Examples
         i. $(2 \times 10^3)(1.5 \times 10^2) = 3 \times 10^5$
         ii. $(2 \times 10^{-2})(3 \times 10^{-4}) = 6 \times 10^{-6}$
   4. Division
      a) The numbers (A's) are divided
      b) The *n*'s are subtracted
      c) Examples:
         i. $10 \times 10^4 / 2 \times 10^2 = 5 \times 10^2$
         ii. $10 \times 10^4 / 2 \times 10^6 = 5 \times 10^{-2}$
   5. On calculators the E or EE button may stand for " x 10"
      a) Examples:
         i. 2E4 → 2×10^4 → 20000
         ii. 1E-3 → 1×10^{-3} → 0.001

II. Precision vs accuracy in measurements

A. Precision – the level of units that the instrument is capable of measuring

1. Examples:
    a) Ruler that measures in 1 mm increments vs a caliper that measures in 0.01 mm increments
    b) A beaker with graduations every 50 ml vs a graduated cylinder with graduations every 1 ml vs a pipet with graduations every 0.1 ml
    c) Micropipets can often measure liquids to the nearest µl or lower!

B. Accuracy – how close the instruments measurements are to the correct value
C. Just because an instrument is precise does not necessarily mean that the measurements are accurate
D. Similarly an instrument can be accurate but not necessarily precise



III. Exercise 2 – MAKING and CONVERTING METRIC MEASUREMENTS

A. Metric units of conversion (large to small)

Prefix	Symbol	Multiplier	Examples
Kilo-	k	10^{3}	kg, km, kl
Base unit	-	-	g, m, l
Deci-	d	10^{-1}	dg, dm, dl
Centi-	c	10^{-2}	cg, cm, cl
Milli-	m	10^{-3}	mg, mm, ml
Micro-	μ	10^{-6}	μg, μm, μl
Nano-	n	10^{-9}	ng, nm, nl

1. When converting between units remember the following rules:
    a) When converting from large units to smaller units the decimal point will move to the right
    b) When converting from small units to larger units the decimal point will move the left
    c) The decimal will move a number of places equal to the multiplier exponent of the small unit subtracted from the multiplier exponent of the larger unit

B. Length

1. Typically measured with a ruler or calipers
2. Metric units of measure

Unit	Meters
Kilometer	1×10^{3}
Meter	1
Decimeter	1×10^{-1}
Centimeter	1×10^{-2}
Millimeter	1×10^{-3}
Micrometer	1×10^{-6}
Nanometer	1×10^{-9}

3. Practice the conversions in the lab manual

C. Mass

1. Typically measured with a digital scale

2. Metric units of measure

Unit	Grams
Kilogram	1×10^{3}
Gram	1
Decigram	1×10^{-1}
Centigram	1×10^{-2}
Milligram	1×10^{-3}
Microgram	1×10^{-6}
Nanogram	1×10^{-9}

3. Practice the conversions in the lab manual
4. Practice using a digital scale to measure objects in the lab

D. Volume

1. Typically measured with graduated cylinders, pipets and micropipets
2. Metric units of measure

Unit	Liters
Kiloliter	1×10^{3}
Liter	1
Deciliter	1×10^{-1}
Centiliter	1×10^{-2}
Milliliter	1×10^{-3}
Microliter	1×10^{-6}
Nanoliter	1×10^{-9}

3. Practice the conversions in the lab manual
4. Practice using a micropipette
5. Practice using a graduated cylinder
    a) Learn how to properly read a meniscus

E. Temperature

1. Celsius (°C), Fahrenheit (°F) and Kelvin (K)
2. This laboratory will focus on Celsius and Fahrenheit
3. $°C = (°F - 32)(5/9)$
4. $°F = (°C \times (9/5)) + 32$
5. Practice the conversions in the lab manual