1. Two environmentally conscious neighbors in Canada decide to set their house thermostats lower during winter in order to reduce their energy usage. One neighbor's thermostat uses Fahrenheit, and the other uses Celsius for temperature. One neighbor lowers the thermostat by 5.5°F, and the other neighbor lowers the thermosat by 3°C. If the two houses were equally warm before, which house will be colder than the other one after the two neighbors change the settings?
   A) The one with Fahrenheit
   B) The two houses will be equally cold
   C) The one with Celsius
   D) It depends on what temperature they start with.
   E) It depends on whether the new temperature is above or below freezing point of water.

* Note that the question involves changes in temperature.
* We must use the relative sizes of the degrees in °F & °C.
* We cannot use the usual conversion formula for changes in temperature.

For changes in temperature, ΔT:

$$\Delta T_{°F} = \left(\frac{9\,°F}{5\,°C}\right)\Delta T_{°C} = 1.8\,\Delta T_{°C}$$

So, a change of −3°C corresponds to

$$\Delta T_{°F} = (1.8)(-3) = -5.4\,°F$$

The house with a 5.5°F reduction in temperature will be colder (barely, by just 0.1°F!)

2. On the fictional planet of Unifactoria, two commonly used length units are related to one another by the following exact conversion:
   1 greg = 31 blegs

   How many <u>cubic blegs</u> are there in 107 <u>cubic gregs</u> of volume?
   A) 3.32×10^{3}
   B) 3.59×10^{-3}
   C) 1.11×10^{-1}
   D) 3.19×10^{6}
   E) 1.03×10^{5}

We first obtain the conversion between bleg^3 and greg^3 by cubing the relationship between the length units:

$$(1\,\text{greg})^3 = (31\,\text{bleg})^3$$

$$1\,\text{greg}^3 = 29791\,\text{bleg}^3$$

(we do keep all the digits in 29791 since the conversion relationship is exact)

Then we apply dimensional analysis

$$\underbrace{107}_{\text{3 sig. figs.}}\,\cancel{\text{greg}^3} \times \frac{29791\,\text{bleg}^3}{1\,\cancel{\text{greg}^3}} = \underbrace{3.19 \times 10^{6}}_{\text{3 sig. figs.}}\,\text{bleg}^3$$

3. *For this question, remember that we are using a more fundamental way of classifying mixtures than the textbook. Also note that not everything is necessarily a mixture.*
   If a liquid looks clear,
   A) it must be a homogeneous mixture
   B) it may be a solution, a heterogenous mixture with clumps smaller than the wavelength of visible light, or a pure liquid
   C) it must be a pure liquid
   D) it must be a heterogenous mixture
   E) it must be either a solution or a pure liquid

Contrary to what you might read in oversimplified sources, a mixture that looks clear (not cloudy) may or may not be homogeneous.
If the "clumps" are smaller than the wavelength of visible light, it will look clear even if the clumps make the mixture heterogeneous.
And of course the clear liquid can simply be a pure liquid

4. What is the best answer to report for $(627 \times 0.0039) + 24.29$?
   A) 27
   B) 26.7
   C) 26.735
   D) 26.7353
   E) 26.74

$\underbrace{627 \times 0.0039}$ + 24.29

* handled first, with or without parentheses
* keep track of no. of sig. figs not decimals

3 s.f. 2 s.f.

$\underbrace{627 \times 0.0039} + 24.29$

2.4453
2 s.f.

2.4453 + 24.29

for addition & subtraction, we keep track of decimal places

ends at the 0.1's place

ends at the 0.01's place

26.7353

ends at the 0.1's place

round to 0.1's place $\Rightarrow$ 26.7

5. Report the average of the following numbers with the appropriate precision:
86, 24, 57, 66, 13, 89
A) 56
B) 55.83
C) 55.8
D) 60
E) 60.

Averaging involves adding up the numbers and then dividing the result by the number of data points.

All the numbers end at the 1's decimal place
The sum of the numbers should also end at the 1's.

$86 + 24 + 57 + 66 + 13 + 89 = 335$

ends at the 1's place but because it gained a digit at the 100's place, it gained a significant figure

$$\text{Average} = \frac{\overset{3\text{ s.f.}}{335}}{\underset{\text{infinite sig. figs (it's an exact count)}}{6}} = \overset{3\text{ s.f.}}{55.8}$$

6. Classify the following statements:

I. Magnets of various strengths and compositions were placed near other magnets and the magnitude and direction of the force on a set of points on each magnet was measured as the relative orientation of the two magnets was changed.
II. A magnet suspended on a string kept returning back to a particular direction no matter how I turned it around.
III. Free-floating magnets always align in the north-south direction.
IV. Earth's magnetic field (which is in a north-south direction) applies a torque (a kind of force that can cause rotation) on a magnet. The torque disappears only when the magnet is pointing in the same direction as the magnetic field.
V. Magnets align in the north-south direction because there is more iron near the north pole than the south pole.

A) I. Observation; II. Law; III. Experiment; IV. Theory; V. Hypothesis
B) I. Law; II. Experiment; III. Observation; IV. Hypothesis; V. Theory
C) I. Experiment; II. Observation; III. Law; IV. Theory; V. Hypothesis
D) I. Experiment; II. Hypothesis; III. Law; IV. Theory; V. Observation
E) I. Theory; II. Observation; III. Hypothesis; IV. Law; V. Experiment

I. Describes a set of controlled, organized observations which would be described as "experiments"

II. Describes a single, casual observation

III. Makes a statement about a behavior in nature with no further explanation. It is stating a "law".

IV. Provides an explanation for the observed behavior of magnets. It is best classified as a "theory"

V. It provides an explanation for the behavior of magnets, but the explanation is not based on proven facts (hopefully we all know it's not really the reason why magnets align in the north-south direction). It is just a "hypothesis".

7. On the fictional planet of Nofactori, two commonly used mass units are related to one another by the following exact conversion:

   1 grul = 13 blals

   How would scientists on Earth, using SI prefixes, express 241 gruls in terms of *kilo*blals?

   A) 1.85×10^4
   B) 3.13×10^6
   C) 1.85×10^{-14}
   D) 3.13×10^0
   E) 4.07×10^{-26}

$$241 \cancel{\text{grul}} \times \frac{13 \cancel{\text{blal}}}{1 \cancel{\text{grul}}} \times \frac{1 \text{ kiloblal}}{10^3 \cancel{\text{blal}}} = 3.13 \times 10^0 \text{ kiloblal}$$

8. At what temperature do we have $T_{°F} = 3.2\, T_{°C}$?

$$T_{°F} = T_{°C} \times \left(\frac{9°F}{5°C}\right) + 32°F$$

   (Ignore significant figure considerations.)

   A) 6.4 °C
   B) 22.9 °C
   C) 10 °C
   D) 4.7 °C
   E) 88.9 °C

$$T_{°F} = 3.2\, T_{°C}$$

substitute

$$T_{°F} = 1.8\, T_{°C} + 32$$

$$3.2\, T_{°C} = 1.8\, T_{°C} + 32$$

$$1.4\, T_{°C} = 32$$

$$T_{°C} = \frac{32}{1.4} = 22.9\ °C$$

9. A 15.3 mL sample of a liquid has a mass of 29.4 grams. What is the mass of a 58-mL sample of this liquid?
A) 30 g
B) 111 g
C) 2.6×10^4 g
D) 58 g
E) 7.7 g

We can first find the density from the given mass & volume and then use it to convert any volume to mass

$$d = \frac{m}{V} = \frac{29.4\,g}{15.3\,mL} = 1.92\,g/mL$$

$$d = \frac{m}{V} \Longrightarrow m = d \cdot V = 1.92\,\frac{g}{mL} \times 58\,mL = 111\,g$$

unfortunately we must ignore the sig. fig. considerations, as the result should have only two sig. figs. Technically we should report it as 1.1×10^2 g

Alternatively, we can apply dimensional analysis directly:

$$58\,\cancel{mL} \times \frac{29.4\,g}{15.3\,\cancel{mL}} = 111\,g$$

10. Label each data set below as 'accurate' or 'not accurate' and 'precise' or 'not precise'. Don't necessarily follow your intuition about what "looks" or "feels" precise or accurate. Follow the functional definitions given in the lectures. Examine the numbers for their "claim", given their decimal places and their implicitly allowed uncertainties.

Measurements	True value
I) 4.154, 4.153, 4.149	4.194
II) 7.52, 7.53, 7.50	7.51
III) 5.1, 5.7, 5.7	6.835

I) 4.154, 4.153, 4.149 have the same number of digits after the decimal point as the true value, so they are precise

Since the numbers are not reported with explicit ± uncertainties we assume the most conservative ±0.009 (i.e. ±9 in the last significant digit of each)

For 4.154: $4.154 - 0.009 = 4.145$, $4.154 + 0.009 = 4.163$ } the claim by "4.154" is the true value lies between 4.145 & 4.163

And the true value is 4.194 ± 0.009

The true value actually is between

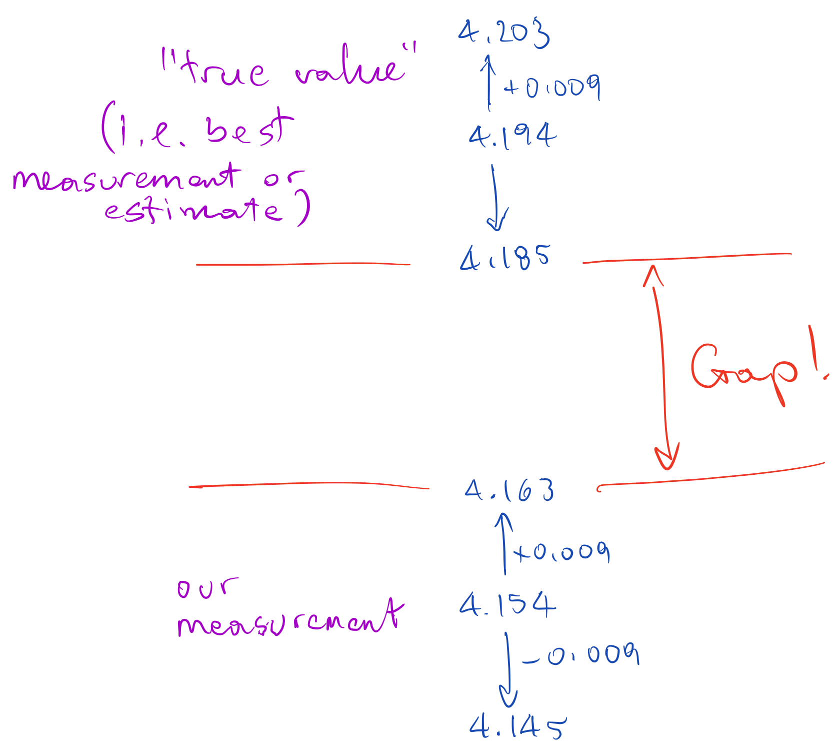
$4.194 - 0.009 = 4.185$

and

$4.194 + 0.009 = 4.203$

Even the minimum of the range in which the true value actually lies is higher than the maximum of the range allowed by 4.154 (which is 4.163)

So 4.154 is not accurate!



Same arguments apply to the other two measurements in I

II) 7.52, 7.53, 7.50 have the same number of digits after the decimal point as the "true value" does, so they are precise

Thinking similarly to what we did for (I),

for 7.52: $7.52 - 0.09 = 7.43$, $7.52 + 0.09 = 7.61$ — The claim by "7.52" is the true value lies between 7.43 & 7.61

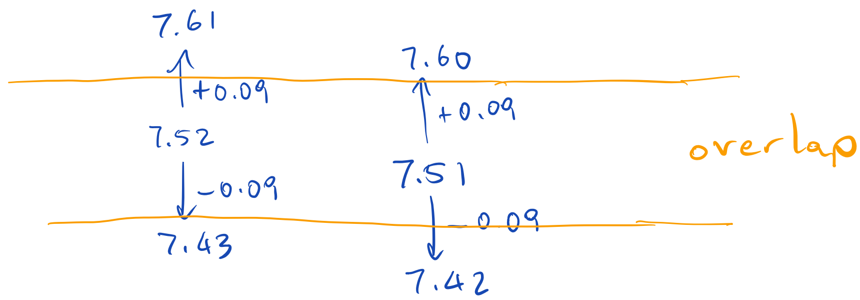
And the true value is <u>actually</u> between

$7.51 - 0.09 = 7.42$

and

$7.51 + 0.09 = 7.60$

The range implied by the data point overlaps with the range implied by the true value



7.52 is accurate

Same arguments apply to the other two measurements in II

III) 5.1, 5.7, 5.7 have fewer digits after the decimal point than the true value, 6.835

So they are not precise

For 5.7: $5.7 - 0.9 = 4.8$, $5.7 + 0.9 = 6.6$ — The claim by "5.7" is the true value lies between 4.8 and 6.6

And the true value is <u>actually</u> between

$6.835 - 0.009 = 6.826$

and

$6.835 + 0.009 = 6.844$

The range implied by the data point does not overlap with the range implied by the true value, so 5.7 is not accurate

Same applies to 5.1