/ (*) Add in density? (Key)



# Unit 1b Practice Packet: Measurements and Calculations in Chemistry

## Scientific Notation

1. To express a number in scientific notation, we write it as a product of two factors. The first is a number falling between 1 and 10. The second is a power of 10. Express the following in scientific notation:

   a. 0.00471 $4.71 \times 10^{-3}$
   b. 2194 $2.194 \times 10^{3}$
   c. 0.01050 $1.050 \times 10^{-2}$
   d. 408,915 $4.08915 \times 10^{5}$
   e. 1,200 $1.2 \times 10^{3}$
   f. 13,090 $1.309 \times 10^{4}$
   g. 0.000018 $1.8 \times 10^{-5}$
   h. 300,000 $3.0 \times 10^{5}$

2. To express a number as a whole number or decimal, we use zeros to locate the decimal point for a value of any size. Express the following as whole numbers or decimals:

   a. $4.19 \times 10^{-3}$ .00419
   b. $8.0 \times 10^{3}$ 8,000
   c. $3.010 \times 10^{-2}$ .03010
   d. $5.08 \times 10^{3}$ 5080
   e. $2.73 \times 10^{-4}$ .000273
   f. $8.180 \times 10^{5}$ 818000
   g. $1.007 \times 10^{-2}$ .01007
   h. $6.915 \times 10^{2}$ 691.5

## Measurement and the Metric System

3. For each of the following metric measurements, circle the prefix and underline the base unit.
   a. 150 kg b. 176 J c. 10 cm d. 45 mL e. 76 kPa f. 18 g

4. Use Reference Table D to determine the physical quantity measured in the following:
   a. 6.30 mL volume
   b. 1.0 atm pressure
   c. 273 K temperature
   d. 89.7 kg mass
   e. 0.5 M concentration
   f. 50 ppm concentration
   g. 164 J energy
   h. 100 kPa pressure

5. Give the metric prefix that responds to each of the following:
   a. 1000 kilo
   b. 0.01 centi
   c. 1,000,000 mega
   d. $10^{-9}$ nano
   e. 0.1 deci
   f. $10^{-3}$ milli

   (*) see Ref. Table C.

6. The table below shows values for the measured widths and lengths of two wooden blocks. Complete the table for the minimum and maximum values based on the recorded measurements.
   For the reported value, underline the certain digits & circle the estimated digit.

| | Smallest Possible (certain) | Reported Measured Value | Largest Possible (certain) |
|---|---|---|---|
| Width | 41.8 | 41.85 cm | 41.9 |
| Length | 62.7 | 62.77 cm | 62.8 |

↑ w/ estimation

7. A student recording the following volume measurements in multiple trials of an experiment. For each of the measurements, underline the certain digit(s) and circle the uncertain/estimation digit(s).

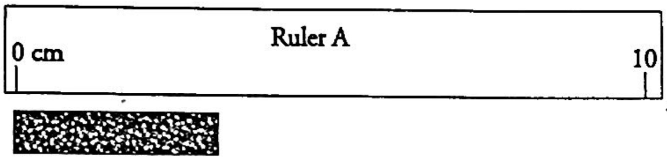
a. 5.97 mL  b. 6.2 mL  c. 6.00 mL  d. 5.99 mL

e. Assuming all of the measurements were recorded correctly, did the student use the same device to take all of the measurements? Explain how you know.

No, because each measurement is NOT recorded using the same number of significant digits. Correct measurements are recorded using all certain digits + 1 estimation, so if these were taken w/ the same device, they'd need to have the same # of s.f.

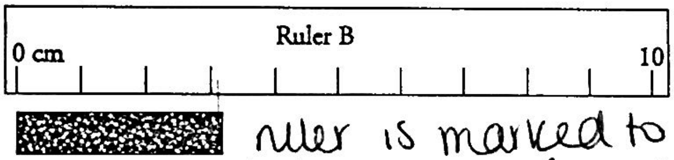
8. The following pictures show measuring devices. Record each measurement displayed to the correct number of significant figures.

a.




3 cm
↑ ones place only!

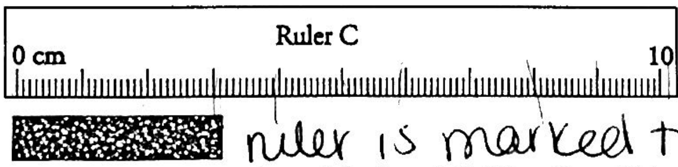
b.




ruler is marked to ones place, so record to tenths

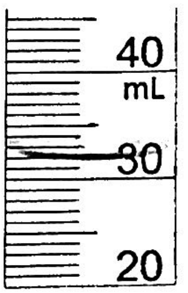
3.2 cm
↑ record to tenths

c.



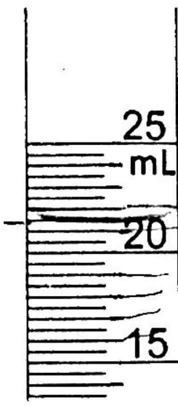

ruler is marked to tenths place, so record to hundreaths

3.15 cm

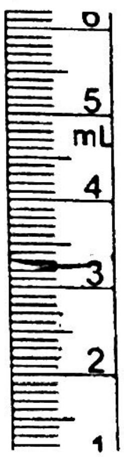



marked to ones, record to tenths

d. 32.0 mL




e. 21.52 mL




f. 3.23 mL

**Significant Figures**

9. Indicate the number of significant figures in each of the following:

a. $6.07 \times 10^{-15}$ 3 sf
b. 0.0003840 4 sf
c. 17.00 4 sf
d. $8 \times 10^{8}$ 1 sf
e. 403.8052 7 sf
f. 300 1 sf
g. 301 3 sf
h. 300. 3 sf
i. 100 1 sf
j. $1.0 \times 10^{2}$ 2 sf
k. $1.00 \times 10^{3}$ 3 sf
l. 100. 3 sf
m. 0.0048 2 sf
n. 0.00480 3 sf
o. $4.80 \times 10^{-3}$ 3 sf
p. $4.800 \times 10^{-3}$ 4 sf

10. Round off each of the following numbers to the indicated number of significant digits.

a. 0.00034159 to three digits
0.000342 or $3.42 \times 10^{-4}$

b. $103.351 \times 10^{2}$ to four digits
$103.4 \times 10^{2}$

c. 17.9915 to five digits
17.992

d. $3.365 \times 10^{5}$ to three digits
$3.37 \times 10^{5}$

11. Use *scientific notation* to express the number 385,500 to:

a. One significant figure 385,500
$4 \times 10^{5}$

b. Two significant figures 385,500
$3.9 \times 10^{5}$

c. Three significant figures 385,500
$3.86 \times 10^{5}$

d. Five significant figures 385,500
$3.8550 \times 10^{5}$

12. Measurements that include inherent uncertainty are often used in calculations. In order to keep the appropriate level of uncertainty, simple rules for the use of significant figures have been developed. Summarize these rules below:

a. For multiplication and division:
Round the final answer to have the same # of s.f. as the quantity with the least sf.

b. For addition and subtraction:
Round the final answer to have the same # of decimal places as the quantity with the fewest decimal places

13. Evaluate each of the following and record the unrounded answer, then the answer rounded to the appropriate number of significant figures.

a. 212.2 + 26.7 + 402.99 unrounded: 641.89 rounded: 641.9
b. 1.0028 + 0.221 + 0.10337 unrounded: 1.32717 rounded: 1.327
c. 52.331 + 26.01 - 0.9981 unrounded: 77.3429 rounded: 77.34
d. $2.01 \times 10^{2} + 3.014 \times 10^{3}$ unrounded: 3215 rounded: 3215

14. Perform the following mathematical operations, and express each result to the correct number of significant figures.

a. $\frac{(0.102 \times 0.0821 \times 273)}{1.01}$ unrounded: 2.263521386 rounded: 2.26 (to 3sf)

*Because this problem only requires one rule (x, ÷), put entire thing into calc, then round.

b. $0.14 \times (6.022 \times 10^{23})$ unrounded: $8.4308 \times 10^{22}$ rounded: $8.4 \times 10^{22}$

(0.14 — 2sf; rounded to 2sf.)

c. $(4.0 \times 10^{4}) \times (5.021 \times 10^{-3}) \times (7.34993 \times 10^{2})$

(4.0 — 2 sf.)

unrounded: 147615.9941 rounded: $1.5 \times 10^{5}$ (to 2 sf.)

d. $(2.00 \times 10^{6}) \div (3.00 \times 10^{7})$

(2.00 — 3sf)

unrounded: $0.0666666\overline{6}$ rounded: 0.0667 or $6.67 \times 10^{-2}$

15. Perform the following calculations and round off each answer to the correct number of significant figures.

a. $\frac{(52.8\ Pa + 3.0025\ Pa)}{253.4\ Pa} = \frac{55.8}{253.4} = \boxed{0.220}$ (round to decimal)

b. $(0.12\ g + 5.16\ g) \times (45.56\ g - 93.0\ g)$ (round to 2 dec. places; round to 1 dec. place; round to 3sf)

$5.28 \times -47.4 = \boxed{-250}$ (round to 3 sf.)

c. $1250\ cal - (\frac{234.207\ cal}{52.69\ cal}) = 1250\ cal - 4.445\ cal$ (4sf)

$= \boxed{1246\ cal}$ ← 0 dec. places

d. $\frac{(78.26\ L + 89.50\ L)}{(678.2\ L + 9511\ L)} = \frac{167.76}{10189} = \boxed{0.016465}$ (2 dec. places; 0 dec. places; round to 5sf)

*when doing calculations involving both x/÷ AND +/−, do the first calculation & round that value to the correct # of s.f. Then, use this rounded # to carry out the next operation.

16. Describe the differences between *accuracy* and *precision.*

- Accuracy - how close to actual/desired value a set of measurements are.
- Precision - how close together/to one another a set of measurements are.

Omit

17. To check the accuracy of a graduated cylinder, a student filled the cylinder to the 25-mL mark using water delivered from a buret and then read the volume delivered. The results of five trials are recorded in the table below. According to these results, is the graduated cylinder accurate? Explain your reasoning using the terms *random error* and *systematic error.*

| Trial | Volume Shown by Graduated Cylinder | Volume Shown by Buret |
|---|---|---|
| 1 | 25 mL | 26.54 mL |
| 2 | 25 mL | 26.51 mL |
| 3 | 25 mL | 26.60 mL |
| 4 | 25 mL | 26.49 mL |
| 5 | 25 mL | 26.57 mL |
| Average | 25 mL | 26.54 mL |

The graduated cylinder is not accurate. There is consistent systematic error in the graduated cylinder; it always measures slightly lower then the actual value.

18. There are 140. calories (accepted value) in one can of Coke. In an experiment you determine that there are 210. (measured value) You are a bit off, but what is your percent error for the experiment? Round your answer to the correct number of significant figures.

$$\% \text{ error} = \frac{\text{measured} - \text{accepted}}{\text{accepted}} \times 100$$

$$= \frac{210. - 140.}{140.} \times 100\% = \boxed{50.\%}$$

19. Working in the laboratory, a student finds the density of a piece of pure aluminum to be 2.85 (measured) g/cm³. The accepted value for the density of aluminum is 2.699 (accepted) g/cm³. Determine the percent error, rounded to the correct significant figures.

$$\% \text{ error} = \frac{\text{measured} - \text{accepted}}{\text{accepted}} \times 100\%$$

round to 2 dec. → round to 2 sf

$$= \frac{2.85 - 2.699}{2.699} \times 100 = \frac{0.15}{2.699} \times 100 = \boxed{5.6\%}$$

20. A student experimentally determines the specific heat of water to be 4.29 J/g x C°. He then looks up the specific heat of water on a reference table and finds that it is 4.18 J/g• C°. What is his percent error? Round to the correct number of significant figures.

measured / accepted

$$\% \text{ error} = \frac{m-a}{a} \times 100\% = \frac{(4.29-4.18)}{4.18} \times 100\% = \boxed{2.39\%}$$

21. A student measures the volume of a substance to be 34.5 mL. What is their percent error for this measurement if the actual volume was 0.0250 L? Round to the correct number of significant figures.

measured / accepted

(*) first, need to convert so units are the same!

$$0.0250\ L \times \frac{1{,}000\ mL}{1\ L} = 25.0\ mL \text{ (actual)}$$

$$\% \text{ error} = \frac{m-a}{a} \times 100\% = \frac{(34.5-25.0)}{25.0} \times 100 = \boxed{38.0\%}$$

22. A chemist determines the density of Copper to be 8.52 g/cm³. Based on the actual density (found on Reference Table S), calculate her percent error to the correct number of significant figures. Why is this percent error negative?

measured

Cu density actual = 8.96 g/cm³

$$\% \text{ error} = \frac{m-a}{a} \times 100\% = \frac{(8.52-8.96)}{8.96} \times 100\% = \boxed{-4.91\%}$$

The % error is (-) because the measured value was lower than the actual value.

**Unit Conversions and Dimensional Analysis**

23. Perform each of the following conversions, showing all work:

a. 8.43 cm to millimeters  cm → m → mm

$$8.43\ cm \times \frac{0.01\ m}{1\ cm} \times \frac{1\ mm}{0.001\ m} = \boxed{84.3\ mL}$$

b. $2.41 \times 10^2$ cm to meters  cm → m

$$2.41 \times 10^2\ cm \times \frac{0.01\ m}{1\ cm} = \boxed{2.41\ m}$$

c. 294.5 nm to centimeters  nm → m → cm

$$294.5\ nm \times \frac{10^{-9}\ m}{1\ nm} \times \frac{1\ cm}{10^{-2}\ m} = \boxed{2.945 \times 10^{-5}}$$

d. $1.445 \times 10^4$ m to kilometers   m → km

$$1.445 \times 10^4 \text{ m} \times \frac{1 \text{ km}}{10^3 \text{ m}} = \boxed{14.45 \text{ km}}$$

e. 235.3 m to millimeters   m → mL

$$235.3 \text{ m} \times \frac{1 \text{ mm}}{10^{-3} \text{ m}} = \boxed{2.353 \times 10^5 \text{ mL}}$$

f. 903.3 nm to micrometers   nm → m → μM

$$903.3 \text{ nm} \times \frac{10^{-9} \text{ m}}{1 \text{ nm}} \times \frac{1 \text{ μm}}{10^{-6} \text{ m}} = \boxed{0.9033 \text{ μM}}$$

24. How many minutes pass in 3.11 hours?   min → hrs

$$3.11 \text{ hrs} \times \frac{60 \text{ min}}{1 \text{ hr}} = 186.6 = \boxed{187 \text{ min}}$$

↑ round to 3 sf

25. How many seconds pass in a day?   days → hrs → min → sec.

⊛ all ∞ s.f.

$$1 \text{ day} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ sec.}}{1 \text{ min}} = \boxed{86{,}400 \text{ sec.}}$$

26. How many seconds are in a year?   year → day → seconds

⊛ all ∞ s.f.

conversion factor found in #25.

$$1 \text{ year} \times \frac{365 \text{ days}}{1 \text{ yr}} \times \frac{86{,}400 \text{ sec}}{1 \text{ day}} = \boxed{3.1536 \times 10^7 \text{ sec.}}$$

27. How old are you in seconds? (Use your age to the nearest year.)   yrs → days → sec.

$$15 \text{ yrs} \times \frac{365 \text{ days}}{1 \text{ yr}} \times \frac{86{,}400 \text{ sec}}{1 \text{ day}} = \boxed{1.296 \times 10^6 \text{ sec.}}$$

28. How old are you in dog years? (1 human year = 7 dog years)

$$15 \text{ human yrs} \times \frac{7 \text{ dog years}}{1 \text{ human yr}} = \boxed{105 \text{ dog yrs}}$$