

**Chemistry 105**  
**Homework Set # 1 (25 points)**  
**Due Sunday, September 19**

These questions are from chapters 1-3 of *Chemistry for Changing Times* and Chapters 1 & 6 of *Colour*. You will also find helpful information in the virtual lecture notes for Discussions 1-3.

**Scientific Notation, Unit Conversions and the scientific method.**

1. Write the following numbers in standard notation: (*See text, Appendix A.2 and Discussion 1 Notes*)

(a) $4.51 \times 10^{-2}$	<i>Ans: 0.0451</i>	(f) $4.97 \times 10^{-3}$	<i>Ans: 0.00497</i>
(b) $1.3 \times 10^4$	<i>Ans: 13,000</i>	(g) $8.3 \times 10^9$	<i>Ans: 8,300,000,000</i>
(c) $7.2 \times 10^{-3}$	<i>Ans: 0.0072</i>	(h) $4.332 \times 10^{-6}$	<i>Ans: 0.000004332</i>
(d) $9.60 \times 10^{-4}$	<i>Ans: 0.000960</i>	(i) $3 \times 10^{-1}$	<i>Ans: 0.001</i>
(e) $2.123 \times 10^1$	<i>Ans: 21.23</i>		

2. Write each of the following measured numbers in scientific notation with the correct number of significant figures. (*See Notes for Discussion 1 and text, Appendices A.2 and A.4, page A-9*)

(a) 0.8080	<i>Ans: <math>8.080 \times 10^{-1}</math></i>	(e) 0.042	<i>Ans: <math>4.2 \times 10^{-2}</math></i>
(b) 0.079	<i>Ans: <math>7.9 \times 10^{-2}</math></i>	(f) 270,000	<i>Ans: <math>2.7 \times 10^5</math></i>
(c) 6,320	<i>Ans: <math>6.32 \times 10^3</math></i>	(g) 0.00000108	<i>Ans: <math>1.08 \times 10^{-6}</math></i>
(d) 17,500	<i>Ans: <math>1.75 \times 10^4</math></i>	(h) 91,000,000	<i>Ans: <math>9.1 \times 10^7</math></i>

3. Chapter 1 discusses the steps involved in the scientific method. Describe the scientific method in your own words.

*Consult the text - important points include observation, hypotheses, experiments and theories and laws. Some mention of the cyclic nature of scientific inquiry is also necessary.*

4. Describe the difference between a hypothesis and a theory. Include the characteristics of a scientific hypothesis.

*A hypothesis is an educated guess that is informed by one's observations. An important characteristic of a hypothesis is that it is falsifiable - that is one could design an experiment to disprove the hypothesis - it is testable. A theory is the best current explanation for a set of physical phenomena. One can use a theory to make predictions. Theories may be modified or tossed aside when new observations contradict predictions based on the theories. Neither theories nor hypotheses are ever proven absolutely.*

5. Review Sections 1.10 (pages 16-21) and Appendix A.3 (pages A-5 through A-8) in the text and complete the following problems. Show all your work, including conversion factors.

- (a) Convert 234 eggs into dozens.

$$\frac{234 \text{ eggs}}{1} \times \frac{1 \text{ dozen}}{12 \text{ eggs}} = 19.5 \text{ dozen}$$

- (b) Convert 200 centimeters into meters.

$$\frac{200 \text{ cm}}{1} \times \frac{1 \text{ m}}{100 \text{ cm}} = 2 \text{ m}$$

- (c) Convert 0.267 liters into milliliters.

$$\frac{0.267 \text{ L}}{1} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 267 \text{ mL}$$

- (d) Convert 22 centimeters into meters.

$$\frac{22 \text{ cm}}{1} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.22 \text{ m}$$

- (e) Convert 32 pints into deciliters.

$$\frac{32 \text{ pints}}{1} \times \frac{1 \text{ quart}}{2 \text{ pints}} \times \frac{0.946 \text{ L}}{1 \text{ quart}} \times \frac{10 \text{ dL}}{1 \text{ L}} = 151 \text{ dL}$$

- (f) Convert 45 inches into meters

$$\frac{45 \text{ in}}{1} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 1.14 \text{ m}$$

- (g) Convert 25 miles per hour into kilometers per minute.

$$\frac{25 \text{ mi}}{\text{hr}} \times \frac{1 \text{ hour}}{60 \text{ min}} \times \frac{1 \text{ km}}{0.621 \text{ mi}} = 0.67 \text{ km/min}$$

- (h) At a speed of 65 miles per hour, how many minutes will it take to drive 300 kilometers? (hint: start with 300 kilometers and use 60 miles = 1 hour as a conversion factor, then convert hours to minutes.)

*NOTE: there is a typo in the above problem. It should say "use 65 miles = 1 hour as a conversion factor"*

$$\frac{300 \text{ km}}{1} \times \frac{0.621 \text{ mi}}{1 \text{ km}} \times \frac{1 \text{ hr}}{65 \text{ mi}} \times \frac{60 \text{ min}}{1 \text{ hour}} = 172 \text{ min}$$

### Light: Frequency, Wavelength and Energy

6. Convert 575 nm into meters. What color of light does this correspond to?

$$\frac{575 \text{ nm}}{1} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} = 5.75 \times 10^{-7} \text{ m}$$

*Yellow light*

7. Ultraviolet light has wavelengths in the
- $4 \times 10^{-4} \text{ m}$
- to
- $1 \times 10^{-9} \text{ m}$
- range. Convert this range to micrometers (
- $\mu\text{m}$
- ).

$$\frac{10^{-4} \text{ m}}{1} \times \frac{1 \times 10^6 \mu\text{m}}{1 \text{ m}} = 100 \mu\text{m}$$

$$\frac{10^{-9} \text{ m}}{1} \times \frac{1 \times 10^6 \mu\text{m}}{1 \text{ m}} = 0.001 \mu\text{m}$$

*The range is 100-0.001  $\mu\text{m}$*

8. Angstroms (
- $\text{\AA}$
- ) is a length unit commonly used in chemistry. There are
- $1 \times 10^{10} \text{\AA}$
- in one meter. Convert the visible wavelength range of 400-700 nm into Angstroms.

$$\frac{400 \text{ nm}}{1} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} \times \frac{1 \times 10^{10} \text{\AA}}{1 \text{ m}} = 4000 \text{\AA}$$

$$\frac{700 \text{ nm}}{1} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} \times \frac{1 \times 10^{10} \text{\AA}}{1 \text{ m}} = 7000 \text{\AA}$$

*The range is 4000-7000  $\text{\AA}$*

9. Light travels at a speed of  $3.00 \times 10^8$  m/s. Convert this to miles per hour.

$$\frac{3.00 \times 10^8 \text{ m}}{\text{s}} \times \frac{3600 \text{ s}}{1 \text{ hr}} \times \frac{1 \text{ km}}{1000 \text{ m}} \times \frac{0.621 \text{ mi}}{\text{Km}} = \frac{6.7 \times 10^8 \text{ mi}}{\text{hr}}$$

10. What is the frequency of light ( $\nu$ ) associated with a wavelength of 485 nm? (*See Discussion 1 Lecture Notes*)

$$\frac{485 \text{ nm}}{1 \text{ nm}} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} = 4.85 \times 10^{-7} \text{ m}$$

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{4.85 \times 10^{-7} \text{ m}} = 6.16 \times 10^{14} / \text{s}$$

11. What is the wavelength of light associated with a frequency of  $2.6 \times 10^{14}$  per second? (*Discussion 1 Lecture Notes*)

$$\nu = \frac{c}{\lambda}$$

rearranging:

$$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^8 \text{ m/s}}{2.6 \times 10^{14} / \text{s}} = 2.6 \times 10^{-6} \text{ m} = 1154 \text{ nm}$$

12. What is the energy (in Joules) of a photon with a wavelength of 630 nm?

$$\frac{630 \text{ nm}}{1 \text{ nm}} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} = 6.3 \times 10^{-7} \text{ m}$$

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J s})(3.00 \times 10^8 \text{ m/s})}{6.30 \times 10^{-7} \text{ m}} = 3.16 \times 10^{-19} \text{ J}$$

13. What is the energy (in Joules) of a photon with a wavelength of 500 nm?

$$\frac{500 \text{ nm}}{1 \text{ nm}} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} = 5.00 \times 10^{-7} \text{ m}$$

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J s})(3.00 \times 10^8 \text{ m/s})}{5.00 \times 10^{-7} \text{ m}} = 3.98 \times 10^{-19} \text{ J}$$

14. Which has more energy: green light or blue light? Explain.

*Blue light has a shorter wavelength than green light, therefore blue light has more energy.*

15. Which has more energy: ultraviolet light or x-rays? Explain.

*X-rays have a shorter wavelength than UV light, therefore X-rays have more energy.*

## Atomic Structure

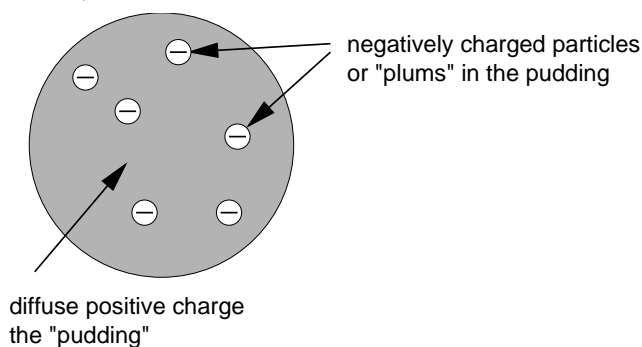
16. The element silicon has three naturally occurring isotopes:  $^{28}\text{Si}$ ,  $^{29}\text{Si}$  and  $^{30}\text{Si}$ . How many protons, neutrons and electrons does each isotope have? (*See text, section 3.5*)

isotope	atomic # = # p <sup>+</sup>	# e <sup>-</sup> = # p <sup>+</sup>	# n <sup>0</sup> = mass # - # p <sup>+</sup>
$^{28}\text{Si}$	14	14	14
$^{29}\text{Si}$	14	15	14
$^{30}\text{Si}$	14	16	14

17. Complete the following table for electrically neutral atoms of the given isotope: (See text, section 3.5)

Symbol	Atomic number	Mass number	number of protons	number of neutrons	Number of electrons
${}_{19}^{38}\text{K}$	19	38	19	19	19
${}_{18}^{38}\text{Ar}$	18	38	18	20	18
${}_{1}^3\text{H}$	1	3	1	2	1
${}_{19}^{39}\text{K}$	19	39	19	20	19
${}_{5}^{11}\text{B}$	5	11	5	6	5
${}_{40}^{90}\text{Zr}$	40	90	40	50	40

18. In the early 1900's a common model for the structure of the atom was the plum pudding model. In this model, negatively charged electrons reside in the atom surrounded by a diffuse, continuous medium of positive charge (like plums in a pudding, or for a more modern analogy, like chocolate chips in a cookie).



(a) In 1911 Earnest Rutherford carried out an experiment that changed the way we view the atom. Describe this gold foil experiment. (See Section 3.4 in the text)

*Alpha particles (He nuclei) from an alpha source were shot at a sample of gold foil. Surrounding this was a zinc sulfide screen designed to detect the alpha particles and measure the angle of deflection.*

(b) How is the plum pudding model inconsistent with Rutherford's experimental findings? Approach this by considering the plum pudding hypothesis, and then predict what you would have expected to happen in Rutherford's experiment if the plum pudding model was true. (See Chapter 1, Section 1.3 for information regarding the scientific method.)

*In the plum pudding model, negatively charged electrons reside in the atom surrounded by a continuous medium of positive charge. At the time, it was believed that this continuous medium of positive charge was very diffuse both in terms of charge and mass. The "pudding" was viewed as having the same amount of charge as the electrons, but that charge was spread out over the whole atom, as was the mass of the atom. Thus, Rutherford's hypothesis was that the alpha particles would pass right through the foil. As they did not all do this, but many were deflected or bounced back, he had to revise the initial hypothesis to account for this. He did this by proposing that the atom has a positively charged nucleus that contained most of the mass of the atom.*

(c) Draw a picture of Rutherford's model of the atom. Use your picture to describe why most of the alpha particles pass through the gold foil in Rutherford's experiment.

*Consult the CfCT text - the diagram on page 68 illustrates this nicely.*