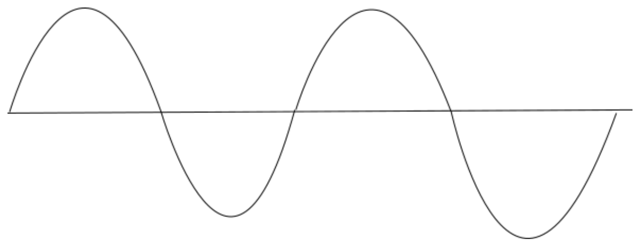
Worksheet 14: Final Exam Review II

1. Using the diagram below, identify the wavelength and amplitude of the wave.



Solution: The wavelength is the crest to crest distance, and the amplitude is the distance from the zero-line to the crest or trough

2. What are the units of frequency for a wave?

Solution: s^{-1} or Hz

3. What is the relation between frequency and wavelength?

Solution: The product of frequency, ν, and wavelength, λ, is the speed of light:

$$c = \lambda\nu$$

4. What is the relation between frequency and energy? What about wavelength and energy?

Solution: Energy is the frequency multiplied by Planck's constant, h:

$$E = h\nu$$

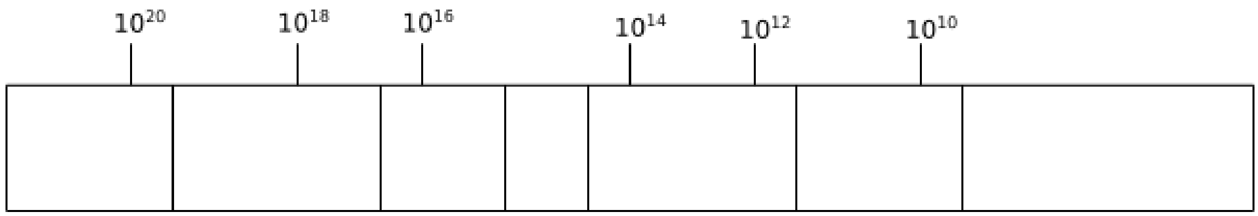
Using the relation above, we can also replace the frequency with $\frac{c}{\lambda}$ to give

$$E = \frac{hc}{\lambda}$$

5. What is a wavenumber?

Solution: Wavenumbers are the inverse of wavelength, often given by the symbol $\tilde{\nu}$.

6. On the figure below, label the types of electromagnetic radiation. Frequency values are shown in Hz.



> **Solution:** In order from left to right, there are γ-rays, x-rays, ultraviolet, visible, infrared, microwave, and radio waves.

7. What is the name for the lowest energy state in a molecule? What about for a higher state?

> **Solution:** The lowest energy state is the ground state, while higher states are referred to as excited states.

8. What are the four crucial components for a single-beam spectrophotometer?

> **Solution:** Light source, wavelength selector (monochromator), sample, and light detector

9. Write the expression for transmittance and define each of the terms.

> **Solution:**
> $$T = \frac{P}{P_0}$$
> T is transmittance, P is the irradiance or intensity of the light emerging from the sample, and P_0 is the intensity of the light entering the sample.

10. How does absorbance relate to transmittance?

> **Solution:**
> $$A = \log\left(\frac{P_0}{P}\right) = -\log T$$

11. What is Beer's law? What do each of the terms mean and when does it break down?

> **Solution:** Beer's law is
> $$A = \epsilon bc$$
> and A is absorbance as defined above, ϵ is the molar absorptivity, b is the path length, and c is the concentration of the solution. Beer's law is useful for monochromatic radiation passing through dilute solution in which the absorbing species is not participating in a concentration-dependent equilibrium.

12. What part of the molecule is responsible for light absorption?

Solution: The chromophore

13. What type of radiational transition is associated with fluorescence? What about with phosphorescence? Which one is higher in energy?

Solution: Fluorescence is associated with an $S_1 \rightarrow S_0$ transition, while phosphorescence is associated with a $T_1 \rightarrow S_0$ transition. Fluorescence is higher in energy.

14. What is the difference between an internal conversion and an intersystem crossing?

Solution: An internal conversion is a nonradiative transition between states with the same spin, while an intersystem crossing is a nonradiative transition between states with different spins.

15. What makes luminescence so much more sensitive than absorbance? What modifications are necessary to make a luminescence spectrophotometer?

Solution: The example in the book is a stadium full of people with candles. Whereas absorbance is like trying to see 500 out of 50,000 people blowing out their candles, luminescence is like seeing only 500 people light their candles. To conduct a luminescence experiment, the detector must be placed out of the line of the light source, usually at a right angle to the path of the light.

16. If we want to decrease the absolute uncertainty of our mean by a factor of 5, by what factor must we increase our number of samples?

Solution:

$$e = \mu - \overline{x} = \frac{ts_s}{\sqrt{n}}$$

We must increase our number of samples by a factor of 25 since the uncertainty, e, scales with the square root of our number of samples, n.

17. What are the two main types of experimental error? Explain the effects of each on precision and accuracy.

Solution: The two main types of experimental error are systematic or determinate error and random or indeterminate error. Systematic error primarily affects accuracy by systematically shifting your results away from the accepted value. Random error primarily affects precision by introducing random variation between measurements.

18. Determine the type of error associated with each of the following.
    (a) A pH meter was standardized incorrectly by the TA
    (b) You are forced to read in between the lines on the graduated cylinder
    (c) A manufacturer does not calibrate a buret before it leaves the factory

(d) The air conditioner turns on and off during your experiment

Solution:
(a) Systematic
(b) Random
(c) Systematic
(d) Random

19. How is the additivity of error different for addition and subtraction when compared to multiplication and division?

Solution: The total uncertainty in an addition or subtraction is found using the absolute uncertainty, while that for multiplication and division is found using relative uncertainties.