JOE PERFECT

Practice Test – Chapter 6 – Atomic Structure

Target 1: I can use $\lambda\upsilon = c$ to solve for the wavelength or the frequency of a wave.

1. Circle the 2 true statements.

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

   [✓ a.] Wavelength and frequency are inversely related.
   b. The speed of light is faster for gamma rays than for yellow light. SAME
   c. The longer the wavelength of a wave, the higher the frequency of the wave.
   [✓ d.] Units of frequency include Hertz, cycles/sec, 1/sec and s^{-1}.
   e. The speed of light is slower than the speed of sound.

2. What is the frequency of ultraviolet radiation with a wavelength of 15.3 nm?

   [✓ a.] $1.96 \times 10^{16}\ s^{-1}$
   b. $1.96 \times 10^{7}\ s^{-1}$
   c. $4.59\ s^{-1}$
   d. $4.59 \times 10^{-9}\ s^{-1}$

$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ m/s}{1.53 \times 10^{-8}\ m} \approx 2 \times 10^{16}\ s^{-1}$

↳ $15.3 \times 10^{-9}\ m$
$1.53 \times 10^{-8}\ m$

Target 2: I can describe the component parts of the electromagnetic spectrum.

3. List the various parts of the electromagnetic spectrum in order from highest energy to lowest energy.

GAMMA RAYS   X-RAYS   UV $\underbrace{\text{VISIBLE}}_{\text{VIBGYOR}}$ IR   MICRO-WAVES   RADIO WAVES

highest E
highest ν
shortest λ

lowest E
lowest ν
longest λ

4. Which type of light has the highest frequency waves?

   a. orange   b. green   [✓ c.] blue   d. red   e. yellow

Target 3: I can explain Max Planck's quantum theory and its significance to understanding the structure of matter.

5. The smallest quantity of energy that can be emitted or absorbed is called a(n) __________ .

   a. electron   b. proton   [✓ c.] quantum   d. X-ray   e. spectrum

   or photon

6. According to Planck's theory, energy can be emitted in whole number multiples of ________ .

   [✓ a.] $h\upsilon$ b. the speed of light   c. Planck's constant   d. $c\lambda$

7. Planck's Quantum Theory was eventually used to help us understand that . . .
    - [✓ a.] electrons can only exist in specific energy states.
    - b. energy can be either continuous or discrete, depending upon the situation.
    - c. protons hold the electrons in the atom.
    - d. we cannot know the exact position and momentum of an object such as an electron.
    - e. it is nearly impossible to remove an electron from an atom.

Target 4: I can explain how Einstein accounted for the photoelectric effect and its significance to understanding the structure of matter.

8. The photoelectric effect occurs when light is shined on a metal surface and . . .
    - a. the metal melts just slightly.
    - b. the metal changes its composition from one element to another.
    - c. an electron combines with a proton to form a neutron.
    - d. an electron combines with a neutron to form a proton.
    - [✓ e.] an electron is emitted.

↳ assuming the light has enough energy!

↑ This energy is known as the "work function.

9. Through Einstein's study of the photoelectric effect, Einstein deduced that . . .
    - [✓ a.] the energy of a photon must equal to hυ.
    - b. some electrons have a greater mass than others.
    - c. some electrons have a greater charge than others.
    - d. it is nearly impossible to remove an electron from an atom.
    - e. protons hold electrons in the atom due to the positive charge of the proton.

10. Which **one** of the following statements is FALSE?
    - a. Photons striking a metal surface can transfer their energy to an electron.
    - b. *Work function* is the term used to describe the minimum amount of energy needed to remove an electron from a metal atom.
    - [✓ c.] The greater the energy of a photon striking a metal surface, the brighter the light emitted. The brightness of the light is related to the # of photons striking the metal per second.
    - d. Einstein won the 1921 Nobel Peace Prize in Physics for his work with the photoelectric effect.
    - e. According to Einstein's work with the photoelectric effect, light is assumed to act as particles and not waves.

Target 5: I can explain the origin and difference between a line spectrum and a continuous spectrum. I will also be able to Johann Balmer's contribution to calculating wavelengths of the lines in a line spectrum.

11. Which two of the following are associated with a continuous spectrum?

a. red light   b. black light   [✓ c.] sunlight   [✓ d.] white light   e. yellow & red light

Both of these produce a "rainbow" of colors known as a continuous spectrum.

12. A particular line in a line spectrum is due to ______ . (Choose the best answer.)
    - a. an electron losing energy as it goes from a lower energy state to a higher energy state.
    - [✓ b.] an electron losing energy as it goes from a higher energy state to a lower energy state.
    - c. an electron gaining energy as it goes from a lower energy state to a higher energy state.
    - d. an electron gaining energy as it goes from a higher energy state to a lower energy state.

13. Johann Balmer _______ .
    - a. Discovered yellow light which eventually lead to the basis of Quantum Mechanics.
    - b. Created one of the first continuous spectra's by using white light and a prism.
    - [✓ c.] Used the line spectrum of hydrogen to develop a mathematical relationship between the wavelengths of the light and integers.
    - d. used the Rydberg equation in order to explain the energy levels in an atom.
    - e. determined that light is emitted as electrons go from an excited state to a more stable ground state.

Target 6: I can explain the contributions of Neils Bohr to quantum theory. I will also be able to calculate the energies corresponding to each allowed orbit for an electron in the hydrogen atom. I will also be able to calculate the energy difference between two allowed states.

14. Which ONE of the following is not part of Bohr's model of the atom?
    - a. Only orbits of certain radii exist for electrons.
    - b. An electron does not radiate energy and therefore does not spiral into the nucleus.
    - c. Energy is emitted (or absorbed) as a photon as electrons change from one allowed state to another.
    - [✓ d.] Electrons are found in orbitals. These orbitals have different shapes based upon the amount of energy of the electron. This is part of Schrödingers model of the atom.

15. Which of the following energy transitions would release photons with the greatest energy?
    - a. A transition from n = 2 to n = 5.
    - b. A transition from n = 2 to n = 7.
    - c. A transition from n = 1 to n = 6.
    - d. A transition from n = 6 to n = 5.
    - [✓ e.] A transition from n = 6 to n = 1.

↳ Must fall from a higher state to a lower state.

Target 7: I can explain the work of Louis de Broglie (matter waves) and the contributions that he made to quantum theory. I will be able to calculate the wavelength of a particle given its mass and velocity.

16. Louis de Broglie said that . . .
    - [✓ a.] any moving object will possess a characteristic wavelength.
    - b. all waves have a wavelength and a frequency.
    - c. matter waves are characteristic of light as light has some mass.
    - d. matter waves are not characteristic of light as light has no mass.
    - e. mass of an object is directly proportional to its wavlength.

$$\lambda = \frac{h}{mv}$$

mass (kg) velocity (m/s)

17. The equation used to calculate the wavelength of a particle is _____ .
    a. $\lambda \upsilon = c$ b. $\lambda = c/\upsilon$ [✓ c.] $\lambda = h/mv$ d. $\lambda = h\upsilon/m$ e. λ = ㅉυ/∫ㅛㅐ

Target 8: I can explain the Heisenberg uncertainty principle.

18. The Heisenberg uncertainty principle states that . . .
    - a. the mass and velocity of an electron can never be determined.
    - b. the mass or velocity of an electron can never be determined.
    - c. the location and mass of an electron can never be determined.
    - d. the momentum and/or the velocity of an electron cannot be simultaneously determined.
    - [✓ e.] the location and momentum of an electron cannot be simultaneously determined.

Target 9: I can explain the concepts of energy shell, subshell, and orbitals as descibed by the quantum-mechanical model of the atom.

19. Which ONE of the following statements is NOT true regarding Schrodinger's quantum mechanical model of the hydrogen atom?
    - a. The exact location of an electron cannot be determined. Only a statistical probability of the location of the electron can be determined.
    - [✓ b.] The motion of electrons can be described by "orbits" as the electron travels around the nucleus in an elliptical fashion.
    - c. The orbitals in an electron cloud have a characteristic shape and energy.
    - d. The collection of orbitals with the same value of "n" make up an energy shell.
    - e. The orbitals having the same value of "n" and "*l*" make-up subshells.

20. Fill in the blanks with the correct number.

6 a) The maximum number of electrons possible in the 5p subshell.

5 b) The number of orbitals in the 3d subshell.

3 c) The value of the "*l*" representing an f-subshell.

32 d) The maximum number of e- possible in the 4th energy shell.

$s = 0$ $d = 2$

$p = 1$ $f = 3$

$2n^2 = 2 \cdot 4^2 = 32e^-$

There are several anomalous e^- configs. Other elements of note are Cr, Mo, Ag & Au.

Target 10: I can write electron configurations and draw orbital diagrams. I can state Hund's Rule and the Pauli Exclusion Principle and I am able to recogize violations of these rules.

21. For a selenium atom (Z=34) . . .
    a) Write the complete electron configuration. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$
    b) Write the shorthand electron configuration. $[Ar]\,4s^2 3d^{10} 4p^4$
    c) Draw an orbital diagram using lines and arrows.

↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑ ↑
1s	2s	2p	3s	3p	4s	3d	4p

22. What is unique about the electron configuration of copper?

(less stable) PREDICTED: $[Ar]\,4s^2 3d^9$

(more stable) ACTUAL: $[Ar]\,4s^1 3d^{10}$ → Copper's e^- configuration is slightly different than predicted. A 4s e^- is placed in the 3d subshell.

23. State Hund's rule and the Pauli Exclusion Principle. Draw orbital diagrams to show violations of each of these rules.

HUND'S RULE: in writing orbital diagrams, one must maximize the # of e^- with the same spin

PAULI EXCLUSION: no 2 e^- can have the same set of 4 quantum #'s

HUND'S VIOLATION

$\underbrace{\uparrow\downarrow \quad \uparrow \quad \_\_}_{2p}$

PAULI EX. VIOLATION

$\underset{2s}{\uparrow\uparrow}$

Target 11: I can define the four quantum numbers. I will also be able to write a viable set of quantum numbers for a given electron.

24. Matching – Choose from the following list of quantum numbers which best matches each of the following:

CHOICES:
A- Principle quantum number
B- Angular momentum quantum number sometimes called the AZIMUTHAL QUANTUM NUMBER
C- Magnetic quantum number
D- Spin magnetic quantum number

D a) m_s
C b) m_l
A c) n
B d) l

B e) Has integral vales from 0 to (n – 1).
D f) Can be +1/2 or -1/2.
A g) Must always be positive numbers.
C h) Describes the orientation of an orbital in space.

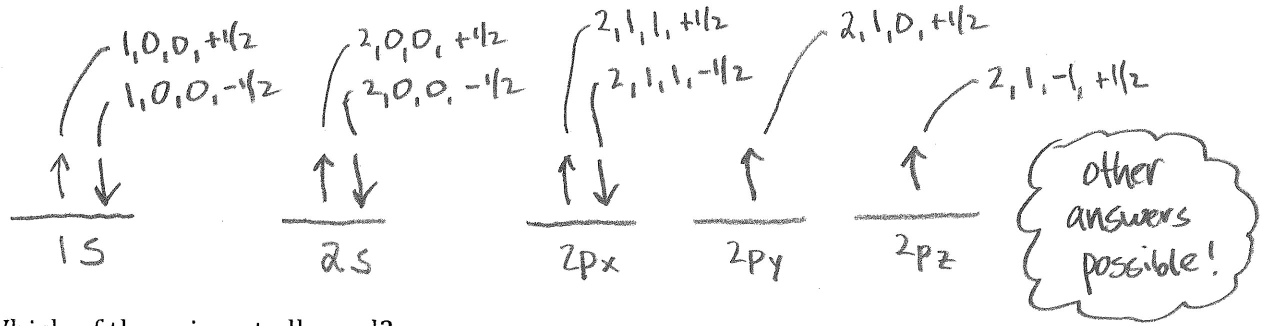
25. What are the possible values of m_l, for l = 3?

a. 3, -3
b. 3, 0, 3
c. 3, 2, 1, -1, -2, -3
[✓ d.] 3, 2, 1, 0, -1, -2, -3

26. Which **two** of the following sets of quantum numbers are **not** viable?

a. 2, 0, 0, -1/2
[✓ b.] 3, 2, 3, +1/2 $m_\ell = +2 \rightarrow -2$
[✓ c.] 4, 0, 1, -1/2 $m_\ell = 0$
d. 5, 3, 2, +1/2
e. 2, 1, -1, -1/2

27. An atom of oxygen has 8 electrons. Write a set of 4 quantum numbers for each of the 8 electrons. $1s^2 2s^2 2p^4$



28. Which of these is not allowed?

a. 2*s* [✓ b.] 2*f* c. 3*p* d. 4*d*

29. Which order of energies of orbitals is correct in a many-electron atom?

a. 2s = 2p [✓ b.] 3s < 3p c. 3d < 2s d. 4s > 5s

Part 2: Answer each of the following questions.

1. The energy required to break a single nitrogen triple bond in a particular molecule is 1,113 kJ/mol. Calculate the wavelength in meters of photons having sufficient energy to break this bond.

2. Calculate the energy (J), frequency (Hz) and wavelength (nm) of a photon released from an electron in a hydrogen atom as an electron falls from n = 7 to n = 2.

3. To what speed (m/s) must a neutron be accelerated in order to have an associated wavelength of 174 pm? (mass of a neutron is 1.675 X 10^{-24} grams)

4. Assume it takes 352 kJ/mol to eject electrons from a certain metal surface. What is the longest wavelength of light (nm) that can be used to eject electrons from the surface of the metal through the photoelectric effect?

5. What is the difference between a Balmer series energy transition and a Lyman series energy transition?

6. What is meant by "degenerate" orbitals? Identify a situation in which a 2s orbital is degenerate with a 2p orbital. Explain your answer.

CHAPTER 6: Part 2 Key

① $$x\ \frac{J}{\text{molecule}} = \frac{1{,}113\ \text{kJ}}{1\ \text{mol}\ N_2}\cdot\frac{1{,}000\ \text{J}}{1\ \text{kJ}}\cdot\frac{1\ \text{mol}\ N_2}{6.02\times10^{23}\ \text{molecules}} = 1.8488\times10^{-18}\ \frac{J}{\text{molecule}\ N_2}$$

$$E=h\nu\ ;\ \nu=\frac{E}{h}=\frac{1.8488\times10^{-18}\ J}{6.63\times10^{-34}\ J\cdot s}=2.789\times10^{15}\ s^{-1}$$

$$c=\lambda\nu\ ;\ \lambda=\frac{c}{\nu}=\frac{3.00\times10^{8}\ m/s}{2.789\times10^{15}\ s^{-1}}=\boxed{1.08\times10^{-7}\ \text{meters}}$$

② $$E_n=\frac{-2.178\times10^{-18}}{n^2}\ J \rightarrow E_2=\frac{-2.178\times10^{-18}}{2^2}=-5.445\times10^{-19}\ J$$

$$E_7=\frac{-2.178\times10^{-18}}{7^2}=-4.445\times10^{-20}\ J$$

$$\Delta E=E_f-E_i=E_2-E_7=-5.445\times10^{-19}\ J-(-4.445\times10^{-20}\ J)=\boxed{-5.001\times10^{-19}}$$

$$E=h\nu\ ;\ \nu=\frac{E}{h}=\frac{5.001\times10^{-19}\ J}{6.63\times10^{-34}\ J\cdot s}=\boxed{7.54\times10^{14}\ s^{-1}}$$

$$\lambda=\frac{c}{\nu}=\frac{3.00\times10^{8}\ m/s}{7.54\times10^{14}\ s^{-1}}=3.98\times10^{-7}\ \text{meters}$$

$$x\ \text{nm}=\frac{3.98\times10^{-7}\ m}{}\cdot\frac{1\times10^{9}\ \text{nm}}{1\ m}=\boxed{398\ \text{nm}}$$

③ $$x\ m=\frac{174\ \text{pm}}{}\cdot\frac{1\ m}{10^{12}\ \text{pm}}=1.74\times10^{-10}\ m$$

$$\lambda=\frac{h}{mv}\ ;\ v=\frac{h}{m\lambda}=\frac{6.63\times10^{-34}\ J\cdot s}{(1.675\times10^{-27}\ kg)(1.74\times10^{-10}\ m)}=2{,}274\ m\ \text{or}\ \boxed{2{,}270\ m}$$

Mass must be in Kilograms!

3 sig. fig's

④ First, calculate frequency of light:

$$X\ s^{-1} = \Bigg|\ \frac{352\ kJ}{1\ mole}\ \Bigg|\ \frac{1{,}000\ J}{1\ kJ}\ \Bigg|\ \frac{1\ mol\ photons}{6.02\times10^{23}\ photons}\ \Bigg|\ \frac{1}{6.63\times10^{-34}\ J\text{-}s}\ \Bigg| = 8.819\times10^{14}\ s^{-1}$$

Next, use frequency to calculate wavelength:

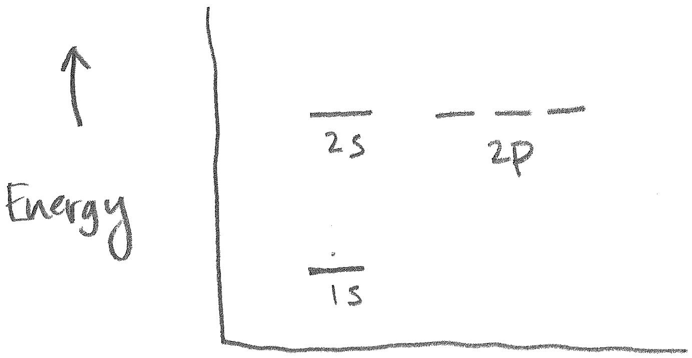
$$\lambda = \frac{c}{\lambda} = \frac{3.00\times10^{8}\ m/s}{8.819\times10^{14}\ s^{-1}} = 3.402\times10^{-7}\ m = \boxed{340.\ nm}$$

⑤ For a Balmer series transition, $n_f = 2$. For a Lyman series transition, $n_f = 1$. A Lyman series transition produces more energetic photons. A Balmer series transition produces visible light.

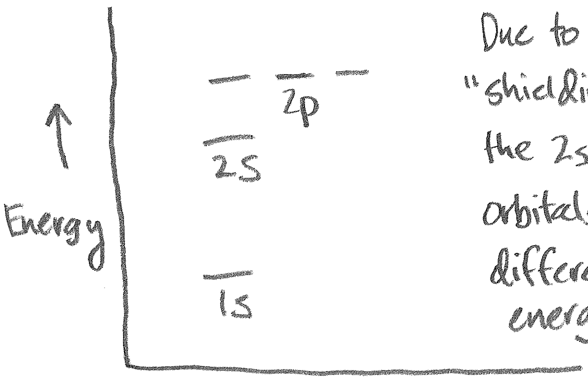
⑥ DEGENERATE ORBITALS are orbitals containing e- with the SAME energy. In a single e- system (H atom, He^+, Li^{2+}, etc.) all orbitals within the same energy shell are degenerate. In a system with more than one e^-, only the orbitals in the same SUBSHELL are degenerate!

For example...

HYDROGEN:



ALL ATOMS EXCEPT HYDROGEN:



Due to the "shielding effect" the 2s & 2p orbitals have different energies.