Chemistry: Structure & Properties, 2e **(Tro)**
Chapter 2: The Quantum Mechanical Model of the Atom

2.1 Multiple Choice Questions

1) The vertical height of a wave is called
A) wavelength.
B) amplitude.
C) frequency.
D) area.
E) median.
Answer: B
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1

2) The number of cycles that pass through a stationary point is called
A) wavelength.
B) amplitude.
C) frequency.
D) area.
E) median.
Answer: C
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1

3) The distance between adjacent crests is called
A) wavelength.

B) amplitude.
C) frequency.
D) area.
E) median.
Answer: A
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1

4) On the electromagnetic spectrum, visible light is immediately between two other wavelengths. Name them.
A) infrared and x-ray
B) radio and microwave
C) gamma ray and ultraviolet
D) microwave and x-ray
E) infrared and ultraviolet
Answer: E
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G1

5) Which of the following visible colors of light has the highest frequency?
A) green
B) red
C) blue
D) yellow
E) orange
Answer: C
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G2

6) Which of the following visible colors of light has the longest wavelength?
A) blue
B) green
C) yellow
D) red
E) violet
Answer: D
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.3

Global: G2

7) Which of the following colors of electromagnetic radiation has the shortest wavelength?
A) blue
B) violet
C) orange
D) green
E) yellow
Answer: B
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G2

8) Which of the following types of electromagnetic radiation has the lowest frequency?
A) yellow
B) blue
C) orange
D) green
E) purple
Answer: C
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G2

9) A sunburn is caused by overexposure to_____radiation.
A) ultraviolet
B) gamma
C) microwave
D) x-ray
E) radio
Answer: A
Diff: 1 Var: 1 Page Ref: 2.2
Global: G2

10) _____are used to image bones and internal organs.
A) Ultraviolet light
B) Gamma rays
C) Microwaves
D) X-rays
E) Radio waves
Answer: D

Diff: 1 Var: 1 Page Ref: 2.2
Global: G2

11) Food can be cooked by_____radiation.
A) ultraviolet
B) gamma
C) microwave
D) x-ray
E) radio
Answer: C
Diff: 1 Var: 1 Page Ref: 2.2
Global: G2

12) When waves of equal amplitude from two sources are out of phase when they interact, it is called
A) destructive interference.
B) diffraction.
C) constructive interference.
D) effusion.
E) amplitude.
Answer: A
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1

13) When waves of equal amplitude from two sources are in phase when they interact, it is called A) destructive interference.
B) diffraction.
C) constructive interference.
D) effusion.
E) amplitude.
Answer: C
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1

14) When a wave encounters an obstacle or a slit that is comparable in size to its wavelength, it bends around it. This characteristic is called A) destructive interference.
B) diffraction.
C) constructive interference.
D) effusion.
E) amplitude.
Answer: B
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1

15) Calculate the wavelength (in nm) of the blue light emitted by a mercury lamp with a frequency of 6.88 × 1014 Hz.

A) 229 nm
B) 436 nm
C) 206 nm
D) 485 nm
E) 675 nm
Answer: B
Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.1
Global: G4

16) Which of the following occur as the energy of a photon increases?
A) The frequency decreases.
B) The speed increases.
C) The wavelength increases
D) The wavelength gets shorter.
E) None of the above occur as the energy of a photon increases.
Answer: D
Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G2

17) Which of the following occur as the wavelength of a photon increases?
A) The frequency decreases.
B) The energy increases.
C) The speed decreases.
D) Planck's constant decreases.
E) None of the above occur as the wavelength of a photon increases.
Answer: A
Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G2

18) Calculate the energy of the green light emitted, per photon, by a mercury lamp with a frequency of 5.49 × 1014 Hz.

A) 2.75 × 10-19 J

B) 3.64 × 10-19 J

C) 5.46 × 10-19 J D) 1.83 × 10-19 J

E) 4.68 × 10-19 J
Answer: B

Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

19) Calculate the energy of the orange light emitted, per photon, by a neon sign with a frequency of 4.89 × 1014 Hz. A) 3.09 × 10-19 J

B) 6.14 × 10-19 J

C) 3.24 × 10-19 J D) 1.63 × 10-19 J

E) 5.11 × 10-19 J

Answer: C
Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

20) Calculate the frequency of the green light emitted by a hydrogen atom with a wavelength of 486.1 nm.

A) 1.46 × 1014 s-1

B) 6.86 × 1014 s-1

C) 4.33 × 1014 s-1

D) 6.17 × 1014 s-1

E) 1.62 × 1014 s-1

Answer: D
Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

21) Calculate the energy of the red light emitted by a neon atom with a wavelength of 703.2 nm.

A) 3.54 × 10-19 J

B) 4.27 × 10-19 J

C) 2.34 × 10-19 J D) 6.45 × 10-19 J

E) 2.83 × 10-19 J

Answer: E
Diff: 3 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

22) Calculate the energy of the violet light emitted by a hydrogen atom with a wavelength of 410.1 nm.

A) 4.85 × 10-19 J

B) 2.06 × 10-19 J

C) 1.23 × 10-19 J D) 8.13 × 10-19 J

E) 5.27 × 10-19 J

Answer: A
Diff: 3 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

23) How many photons are contained in a flash of green light (525 nm) that contains 189 kJ of energy?

A) 5.67 × 1023 photons

B) 2.01 × 1024 photons
C) 1.25 × 1031 photons D) 4.99 × 1023 photons
E) 7.99 × 1030 photons
Answer: D
Diff: 3 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

24) Determine the shortest frequency of light required to remove an electron from a sample of Ti metal, if the binding energy of titanium is 3.14 × 103 kJ/mol.
A) 7.87 × 1015 Hz
B) 4.74 × 1015 Hz
C) 2.11 × 1015 Hz
D) 1.27 × 1015 Hz
E) 6.19 × 1015 Hz
Answer: A
Diff: 3 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

25) What total energy (in kJ) is contained in 1.0 mol of photons, all with a frequency of 2.75 × 1014 Hz?
A) 182 kJ
B) 219 kJ
C) 457 kJ
D) 326 kJ
E) 110 kJ
Answer: E
Diff: 3 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

26) Determine the longest wavelength of light required to remove an electron from a sample of potassium metal, if the binding energy for an electron in K is 1.76 × 103 kJ/mol.
A) 147 nm
B) 68.0 nm
C) 113 nm

D) 885 nm
E) 387 nm
Answer: B
Diff: 3 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

27) Identify the color of a flame test for potassium.
A) violet
B) red
C) white
D) yellow E) blue
Answer: A
Diff: 1 Var: 1 Page Ref: 2.3
Global: G2

28) Identify the color of a flame test for sodium.
A) violet
B) red
C) white
D) yellow
E) blue
Answer: D
Diff: 1 Var: 1 Page Ref: 2.3
Global: G2

29) Identify the color of a flame test for lithium.
A) violet
B) red
C) white
D) yellow
E) blue
Answer: B
Diff: 1 Var: 1 Page Ref: 2.3
Global: G2

30) Which of the following statements is TRUE?
A) The emission spectrum of a particular element is always the same and can be used to identify the element.
B) Part of the Bohr model proposed that electrons in the hydrogen atom are located in "stationary states" or particular orbits around the nucleus.
C) The uncertainty principle states that we can never know both the exact location and speed of an electron.
D) An orbital is the volume in which we are most likely to find an electron.
E) All of the above are true.
Answer: E
Diff: 1 Var: 1 Page Ref: 2.3
Global: G2

31) Calculate the wavelength of an electron (m = 9.11 × 10-28 g) moving at 3.66 × 106 m/s.
A) 1.99 × 10-10 m
B) 5.03 × 10-10 m
C) 1.81 × 10-10 m
D) 5.52 × 10-9 m
E) 2.76 × 10-9 m
Answer: A
Diff: 2 Var: 1 Page Ref: 2.4
LO: 2.4
Global: G4

32) Calculate the wavelength of a baseball (m = 155 g) moving at 32.5 m/s.
A) 7.60 × 10-36 m
B) 1.32 × 10-34 m
C) 2.15 × 10-32 m
D) 2.68 × 10-34 m
E) 3.57 × 10-32 m
Answer: B
Diff: 2 Var: 1 Page Ref: 2.4
LO: 2.4
Global: G4

33) Determine the velocity of a medicine ball (m = 10.0 kg) with a wavelength of 1.33 × 10-35 m. A) 8.81 m/s
B) 12.3 m/s
C) 2.21 m/s
D) 4.98 m/s
E) 6.44 m/s
Answer: D
Diff: 2 Var: 1 Page Ref: 2.4
LO: 2.4
Global: G4

34) Determine the mass of a ball with a wavelength of 3.45 × 10-34 m and a velocity of 6.55 m/s. A) 0.293 g
B) 12.6 g
C) 293 g
D) 346 g
E) 3.41 g
Answer: C
Diff: 2 Var: 1 Page Ref: 2.4
LO: 2.4
Global: G4

35) It is possible to determine the ionization energy for hydrogen using the Bohr equation. Calculate the ionization energy for an atom of hydrogen, making the assumption that ionization is the transition from $n = 1$ to $n = \infty$.
A) -2.18 × 10-18 J
B) +2.18 × 10-18 J
C) +4.59 × 10-18 J
D) -4.59 × 10-18 J
E) +4.36 × 10-18 J
Answer: B
Diff: 1 Var: 1 Page Ref: 2.5
Global: G4

36) For n = 3, what are the possible sublevels?
A) 0
B) 0, 1
C) 0, 1, 2
D) 0, 1, 2, 3
Answer: C
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

37) What are the possible orbitals for $n = 3$?
A) s, p, d
B) s, p, d, f
C) s
D) s, p
Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

38) What value of l is represented by a d orbital?
A) 1
B) 2
C) 0
D) 3
Answer: B
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

39) What value of l is represented by an f orbital?
A) 1
B) 2
C) 0
D) 3
Answer: D
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

40) How many orbitals are contained in the third principal level ($n = 3$) of a given atom? A) 9
B) 3
C) 18
D) 7
E) 5
Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

41) How many sublevels are contained in the second shell ($n = 2$) of a given atom? A) 1
B) 2
C) 9
D) 4

E) 3
Answer: B
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

42) Which of the following statements is TRUE?
A) We can sometimes know the exact location and speed of an electron at the same time.
B) All orbitals in a given atom are roughly the same size.
C) Since electrons have mass, we must always consider them to have particle properties and never wavelike properties.
D) Atoms are roughly spherical because when all of the different shaped orbitals are overlapped, they take on a spherical shape. E) All of the above are true.
Answer: D
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

43) Which of the following quantum numbers describes the shape of an orbital?
A) principal quantum number
B) magnetic quantum number
C) spin quantum number
D) Schrödinger quantum number
E) angular momentum quantum number
Answer: E
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

44) Which of the following quantum numbers describes the orientation of an orbital?
A) magnetic quantum number
B) principal quantum number
C) angular momentum quantum number
D) spin quantum number
E) Schrödinger quantum number Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

45) Which of the following quantum numbers describes the size and energy of an orbital?
A) magnetic quantum number
B) principal quantum number
C) angular momentum quantum number
D) spin quantum number
E) Schrödinger quantum number Answer: B
Diff: 1 Var: 1 Page Ref: 2.5

LO: 2.5
Global: G2

46) How many different values of *l* are possible in the third principal level?
A) 1
B) 2
C) 3
D) 0
E) 4
Answer: C
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

47) If two electrons in the same atom have the same value of "*l*", they are A) in the same sublevel, but not necessarily in the same level.
B) in the same level, but different sublevel.
C) in the same orbital.
D) in different levels and in different shaped orbitals.
E) none of the above.
Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

48) Determine the energy change associated with the transition from $n = 2$ to $n = 5$ in the hydrogen atom.
A) -2.18 × 10-19 J
B) +6.54 × 10-19 J
C) +4.58 × 10-19 J
D) -1.53 × 10-19 J
E) +3.76 × 10-19 J
Answer: C
Diff: 2 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

49) Determine the energy change associated with the transition from $n = 3$ to $n = 2$ in the hydrogen atom.
A) +3.03 × 10-19 J
B) -1.82 × 10-19 J
C) +5.51 × 10-19 J
D) -3.03 × 10-19 J
E) +2.69 × 10-19 J

Answer: D
Diff: 2 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

50) Calculate the energy change associated with the transition from $n = 4$ to $n = 1$ in the hydrogen atom.

A) +4.89 × 10-18 J

B) +1.64 × 10-18 J

C) -6.12 × 10-18 J

D) +3.55 × 10-18 J

E) -2.04 × 10-18 J

Answer: E
Diff: 2 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

51) Which of the following statements is TRUE?

A) The principal quantum number (*n*) describes the shape of an orbital.

B) The angular momentum quantum number (*l*) describes the the size and energy associated with an orbital.

C) The magnetic quantum number (*ml*) describes the orientation of the orbital.

D) An orbital is the path that an electron follows during its movement in an atom.

E) All of the above are true.

Answer: C
Diff: 2 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

52) It is possible to determine the ionization energy for hydrogen using the Bohr equation. Calculate the ionization energy (in kJ) for a mole of hydrogen atoms, making the assumption that ionization is the transition from $n = 1$ to $n = \infty$.

A) 7.62 × 103 kJ

B) 2.76 × 103 kJ

C) 1.31 × 103 kJ D) 3.62 × 103 kJ

E) 5.33 × 103 kJ

Answer: C
Diff: 2 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

53) Calculate the wavelength of light associated with the transition from $n = 1$ to $n = 3$ in the hydrogen atom. A) 103 nm

B) 155 nm
C) 646 nm
D) 971 nm
E) 136 nm
Answer: A
Diff: 3 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

54) Calculate the frequency of light associated with the transition from $n = 2$ to $n = 3$ in the hydrogen atom. A) 2.19 × 1014 s-1

B) 5.59 × 1014 s-1

C) 4.57 × 1014 s-1

D) 1.79 × 1014 s-1

E) 3.28 × 1014 s-1
Answer: C
Diff: 3 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

55) Determine the end (final) value of *n* in a hydrogen atom transition, if the electron starts in $n = 4$ and the atom emits a photon of light with a wavelength of 486 nm.
A) 1
B) 5
C) 3
D) 4
E) 2
Answer: E
Diff: 4 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

56) Determine the end (final) value of *n* in a hydrogen atom transition, if the electron starts in *n* = 2 and the atom absorbs a photon of light with a frequency of 4.57 × 1014 Hz. A)
3
B) 1
C) 4
D) 6
E) 7
Answer: A
Diff: 4 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

57) Determine the end (final) value of *n* in a hydrogen atom transition, if the electron starts in n = 1 and the atom absorbs a photon of light with an energy of 2.044 × 10-18 J. A)
3
B) 4
C) 2
D) 5
E) 6
Answer: B
Diff: 4 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

58) Give the possible values for *ml* for an s orbital.
A) 0
B) -1, 0, 1
C) 0, 1 D) 1
Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

59) Give the possible values for *ml* for a d orbital.
A) 0, 1, 2
B) -1, 0, 1
C) 1, 2, 3
D) -2, -1, 0, 1, 2
Answer: D
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

60) Give the possible values for *ml* for a p orbital.
A) 0, 1
B) -1, 0, 1
C) 1, 2
D) -2, -1, 0, 1, 2
Answer: B
Diff: 1 Var: 1 Page Ref: 2 5
LO: 2 5

Global: G2

61) Give the numbers for *ml* for an f orbital.
A) 0, 1, 2, 3
B) 1, 2, 3, 4

C) -3, -2, -1, 0, 1, 2, 3
D) -2, -1, 0, 1, 2
Answer: C
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

62) Describe the shape of a p orbital.
A) spherical
B) dumbbell shaped
C) three lobes
D) four lobes
E) eight lobes
Answer: B
Diff: 1 Var: 1 Page Ref: 2.6
Global: G2

63) Describe the shape of an s orbital.
A) spherical
B) dumbbell shaped
C) three lobes
D) four lobes
E) eight lobes
Answer: A
Diff: 1 Var: 1 Page Ref: 2.6
Global: G2

64) What is the maximum number of s orbitals that are possible in a given shell?
A) 1
B) 3
C) 7
D) 5
E) 9
Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

65) What is the maximum number of p orbitals that are possible in a given shell?
A) 1
B) 3
C) 7
D) 5
E) 9
Answer: B
Diff: 1 Var: 1 Page Ref: 2.5

LO: 2.5
Global: G2

66) What is the maximum number of d orbitals that are possible in a given shell?
A) 1
B) 3
C) 7
D) 5
E) 9
Answer: D
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

67) What is the maximum number of f orbitals that are possible in a given shell? A) 1
B) 3
C) 7
D) 5
E) 9
Answer: C
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

68) Which statement about electromagnetic radiation is correct? A) The amplitude of a wave depends on the frequency.
B) As the wavelength decreases the energy decreases.
C) As the energy decreases the frequency decreases.
D) The wavelength and frequency are independent of each other.
E) Radio waves have a smaller wavelength than visible light.
Answer: C
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.1
Global: G2

69) What is the frequency of light with a wavelength of 0.440 uM?
A) 6.81 × 1014 sec-1
B) 2.55 × 1013 sec-1
C) 7.28 × 1014 sec-1 D) 6.81 × 1011 sec-1
E) 5.93 × 1011 sec-1
Answer: A
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.1
Global: G4

70) Which of the following types of waves are considered electromagnetic radiation:
A) Radio Waves; B) Sound Waves; C) Microwaves; D) Ocean Waves; E) Mechanical Waves A) A and B
B) A and C
C) B and D
D) A, C, and E
E) B, C, and D
Answer: B
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.1
Global: G2

71) A green laser pointer has a wavelength of 532 nm. What is the energy of one mol of photons generated from this device? A) 2.25 kJ/mol
B) 3.74 × 10-19 kJ/mol
C) 3.74 × 10-17 kJ/mol
D) 225 kJ/mol
E) 784 kJ/mol
Answer: D
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.3
Global: G4

72) A scientist shines light with energy greater than the binding energy of platinum on a thin film of it. The same scientist then repeats the experiment with a higher intensity light. According to the photoelectric effect, what should be observed? A) No electrons are ejected in either experiment.
B) Electrons are not ejected in the first experiment, but are in the second.
C) Electrons are ejected in both experiments, but the first experiment takes longer to eject electrons than the second.
D) Electrons are ejected in both experiments at the exact same time.
E) Electrons are ejected in both experiments, but the second experiment takes longer to eject electrons than the first.
Answer: D
Diff: 1 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G2

73) What is the wavelength of an electron (m = 9.11 × 10-28 g) moving at 1/5 the speed of light?
A) 9.36 × 10-9 m B) 1.21 × 10-11 m
C) 6.73 × 10-8 m
D) 2.42 × 10-12 m
E) 4.85 × 10-10 m

Answer: B
Diff: 1 Var: 1 Page Ref: 2.4
LO: 2.4
Global: G4

74) What is the energy of light associated with a transition from n=3 to n=8 in a hydrogen atom? Does this represent absorption or emission of a photon?

A) 2.08 × 10-19 J, absorption

B) 2.08 × 10-19 J, emission C) 4.54 × 10-19 J, absorption

D) 4.54 × 10-19 J, emission

E) 6.81 × 10-20 J, absorption Answer: A
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

75) How many nodes are found in a 3s orbital?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: C
Diff: 1 Var: 1 Page Ref: 2.6
LO: 2.5
Global: G2

76) How many orbitals are present when *l*=3?
A) 1
B) 3
C) 5
D) 7
E) 9
Answer: D
Diff: 1 Var: 1 Page Ref: 2.6
LO: 2.5
Global: G2

77) According to the Heisenberg Uncertainty Principle
A) an electron can never appear in the exact same position twice.
B) electrons must always absorb energy when moving to higher quantum levels.
C) an electron has a charge of 1.602 × 10-19 C.
D) s orbitals are spherical in nature.
E) you cannot accurately know both the position and momentum of an electron at the same time.
Answer: E

Diff: 1 Var: 1 Page Ref: 2.4
LO: 2.5
Global: G2

78) How many 8p orbitals exist?
A) 0
B) 1
C) 3
D) 5
E) 8
Answer: C
Diff: 1 Var: 1 Page Ref: 2.6
LO: 2.5
Global: G2

79) Calculate the energy change associated with the transition from $n = 6$ to $n = 3$ in the hydrogen atom.
A) +5.35 × 10-19 J
B) -1.83 × 10-19 J
C) -2.42 × 10-19 J D) -4.31 × 10-19 J
E) +6.86 × 10-19 J
Answer: B
Diff: 2 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

80) Calculate the wavelength of light emitted from a mol of photons as they transition from $n = 6$ to $n = 3$ in the hydrogen atom. A) 1093 nm
B) 970 nm
C) 342 nm
D) 643 nm
E) 740 nm
Answer: A
Diff: 4 Var: 1 Page Ref: 2.5
LO: 2.6
Global: G4

81) How many orbitals are associated with an atom when n=5?
A) 4
B) 9
C) 16
D) 25
E) 36
Answer: D
Diff: 1 Var: 1 Page Ref: 2.5

LO: 2.5
Global: G2

82) Calculate the wavelength of a football (425 g) thrown by an NFL quarterback traveling at 50 mph.

A) 4.00 × 10-27 nm

B) 6.60 × 10-25 nm

C) 7.17 × 10-26 nm

D) 3.78 × 10-25 nm

E) 6.97 × 10-26 nm

Answer: E
Diff: 3 Var: 1 Page Ref: 2.4
LO: 2.4
Global: G4

83) Calculate the frequency of the light emitted by a photon with a wavelength of 538.2 nm. A) 7.36 × 1014 s-1

B) 4.84 × 1014 s-1

C) 9.04 × 1014 s-1

D) 3.69 × 1014 s-1

E) 5.57 × 1014 s-1

Answer: E
Diff: 2 Var: 1 Page Ref: 2.2
LO: 2.2
Global: G4

2.2 Algorithmic Questions

1) Electromagnetic radiation with a wavelength of 640 nm appears as orange light to the human eye. The frequency of this light is_____ s^{-1}.

A) 4.688 10^{14} × 10^{5}

B) 4.688 10^{2} × 10^{11}

C) 1.920 10^{-15} ×

D) 1.920 ×

E) 2.133 ×

Answer: A
Diff: 1 Var: 12 Page Ref: 2.2
LO: 2.1
Global: G4

2) An FM radio station broadcasts electromagnetic radiation at a frequency of 92.6 MHz. The wavelength of this radiation is_____m.

A) 3.24×10^{6}
B) 3.24
C) $2.78 \times \frac{10^{16}}{10^{10}}$
D) 2.78 ×
E) 0.309

Answer: B
Diff: 1 Var: 9 Page Ref: 2.2
LO: 2.1
Global: G4

3) Place the following types of electromagnetic radiation in order of increasing wavelength.
ultraviolet light gamma rays microwaves

A) gamma rays < microwaves < ultraviolet light
B) microwaves < ultraviolet light < gamma rays
C) microwaves < gamma rays < ultraviolet light
D) ultraviolet light < gamma rays < microwaves
E) gamma rays < ultraviolet light < microwaves

Answer: E
Diff: 1 Var: 8 Page Ref: 2.2
LO: 2.1
Global: G2

4) Place the following types of electromagnetic radiation in order of increasing frequency.
x-rays infrared light gamma rays

A) infrared light < x-rays < gamma rays
B) gamma rays < x-rays < infrared light
C) infrared light < gamma rays < x-rays D) gamma rays < infrared light < x-rays
E) x-rays < gamma rays < infrared light

Answer: A
Diff: 1 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G2

5) Place the following types of electromagnetic radiation in order of decreasing energy.
gamma rays radio waves infrared light

A) radio waves > infrared light > gamma rays
B) gamma rays > infrared light > radio waves
C) radio waves > gamma rays > infrared light
D) gamma rays > radio waves > infrared light
E) infrared light > radio waves > gamma rays

Answer: B

Diff: 1 Var: 8 Page Ref: 2.2
LO: 2.1
Global: G2

6) Identify the color that has a wavelength of 700 nm.
A) blue
B) green
C) red
D) yellow
Answer: C
Diff: 1 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G2

7) Identify the color that has a wavelength of 480 nm.
A) blue
B) green
C) red
D) yellow
Answer: A
Diff: 1 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G2

8) Identify the color that has a wavelength of 545 nm.
A) blue
B) green
C) red
D) yellow
Answer: B
Diff: 1 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G2

9) Calculate the wavelength (in nm) of a the red light emitted by a neon sign with a frequency of 5.00×1014 Hz.
A) 600 nm
B) 167 nm
C) 500 nm
D) 800 nm E) 200 nm
Answer: A
Diff: 2 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G4

10) Calculate the frequency of the red light emitted by a neon sign with a wavelength of 700 nm.
A) 2.33 × 1014 s-1

B) 4.00 × 1014 s-1

C) 4.29 × 1014 s-1

D) 5.05 × 1014 s-1

E) 3.50 × 1014 s-1
Answer: C
Diff: 2 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G4

11) Electromagnetic radiation with a wavelength of 575 nm appears as yellow light to the human eye. The energy of one photon of this light is_____J.

A) 1.14 × 10-31

B) 3.46 10^{-28} ×

C) 3.46 10^{-19} ×

D) 1.14 × 10-22

E) 2.89 × 10^{18}
Answer: C
Diff: 3 Var: 12 Page Ref: 2.2
LO: 2.2
Global: G4

12) How many photons are contained in a burst of yellow light (589 nm) from a sodium lamp that contains 616 kJ of energy?

A) 2.08 × 1013 photons

B) 3.06 × 1030 photons

C) 1.83 × 1024 photons D) 4.03 × 1028 photons

E) 2.48 × 1025 photons
Answer: C
Diff: 3 Var: 5 Page Ref: 2.2
LO: 2.2
Global: G4
13) How much energy (in kJ) do 3.0 moles of photons, all with a wavelength of 675 nm, contain? A) 177 kJ
B) 354 kJ
C) 418 kJ
D) 532 kJ
E) 238 kJ
Answer: D
Diff: 3 Var: 5 Page Ref: 2.2
LO: 2.2
Global: G4

14) Electromagnetic radiation with a wavelength of 575 nm appears as yellow light to the human eye. The energy of one photon of this light is 3.46×10^{-19} J. Thus, a laser that emits 1.3×10^{-2} J of energy in a pulse of light at this wavelength produces_____photons in each pulse.

A) 2.7×10^{-17}

B) 7.8 × 10-24

C) 2.2 10^{19} × D) 3.8 ×

E) 6.5 10^{16}

× 10^{13}

Answer: D

Diff: 3 Var: 12 Page Ref: 2.2

LO: 2.2

Global: G4

15) The de Broglie wavelength of an electron with a velocity of 7.40 × 106 m/s is_____m. The mass of the electron is 9.11×10^{-28} g.

A) 1.02 × 1010

B) 1.02 × 1013

C) 9.83 × 10-17

D) 9.83 × 10-14

E) 9.83 × 10-11

Answer: E

Diff: 2 Var: 10 Page Ref: 2.4

LO: 2.4

Global: G4

16) Determine the mass of a ball with a velocity of 40.0 m/s and a wavelength of 8.92 × 10-34 m. A) 29.7 g

B) 594 g

C) 2.36 g

D) 53.8 g

E) 18.6 g

Answer: E

Diff: 2 Var: 5 Page Ref: 2.4

LO: 2.4

Global: G4

17) Determine the velocity of a marble (m = 7.75 g) with a wavelength of 3.46 × 10-33 m. A) 40.5 m/s

B) 2.47 m/s

C) 24.7 m/s

D) 38.8 m/s
E) 52.9 m/s
Answer: C
Diff: 2 Var: 5 Page Ref: 2.4
LO: 2.4
Global: G4

18) Which of the following transitions (in a hydrogen atom) represent **emission** of the longest wavelength photon?
A) $n = 1$ to $n = 3$
B) $n = 3$ to $n = 1$
C) $n = 3$ to $n = 5$
D) $n = 4$ to $n = 2$
E) $n = 5$ to $n = 4$
Answer: E
Diff: 1 Var: 12 Page Ref: 2.5
Global: G2

19) Which of the following transitions (in a hydrogen atom) represent **absorption** of the smallest frequency photon? A) $n = 5$ to $n = 6$
B) $n = 5$ to $n = 1$
C) $n = 3$ to $n = 1$
D) $n = 1$ to $n = 4$
E) $n = 1$ to $n = 2$
Answer: A
Diff: 1 Var: 12 Page Ref: 2.5
Global: G2

20) Choose the transition (in a hydrogen atom) below that represents the **absorption** of the shortest wavelength photon.
A) $n = 1$ to $n = 2$
B) $n = 2$ to $n = 3$
C) $n = 4$ to $n = 6$
D) $n = 6$ to $n = 5$
E) $n = 3$ to $n = 1$
Answer: A
Diff: 1 Var: 6 Page Ref: 2.5
Global: G2

21) Which of the following transitions represent the **emission** of a photon with the largest energy? A) $n = 2$ to $n = 1$
B) $n = 3$ to $n = 1$
C) $n = 6$ to $n = 3$
D) $n = 1$ to $n = 4$
E) $n = 2$ to $n = 5$
Answer: B

Diff: 1 Var: 18 Page Ref: 2.5
Global: G2

22) What are the possible values of *n* and *ml* for an electron in a 5 p orbital?

A) *n* = 1, 2, 3, 4, or 5 and *ml* = 1

B) *n* = 1, 2, 3, 4, or 5 and *ml* = -2, -1, 0, +1, or +2

C) *n* = 5 and *ml* = 1

D) *n* = 5 and *ml* = -1, 0, +1

Answer: C
Diff: 1 Var: 4 Page Ref: 2.5
Global: G2

23) How much energy (in kJ) is required to ionize 1.97 moles of hydrogen atoms?

A) 1.29 × 103 kJ

B) 1.19 × 103 kJ

C) 4.29 × 103 kJ D) 2.59 × 103 kJ

E) 5.89 × 103 kJ
Answer: D
Diff: 3 Var: 5 Page Ref: 2.5
Global: G4

24) How many different values of *ml* are possible in the 5d sublevel?

A) 2
B) 1
C) 4
D) 5
E) 8
Answer: D
Diff: 1 Var: 16 Page Ref: 2.5
LO: 2.5
Global: G2

25) How many different values of *ml* are possible in the 2p sublevel?

A) 2
B) 1
C) 3
D) 5
E) 7
Answer: C
Diff: 1 Var: 8 Page Ref: 2.5
LO: 2.5
Global: G2

26) Give all possible values of *l* for a *n*=5 sublevel.
A) 5
B) -1/2
C) 0, 1, 2, 3, 4
D) -3, -2, -1, 0, 1, 2, 3
E) 1, 2, 3, 4, 5
Answer: C
Diff: 1 Var: 10 Page Ref: 2.5
LO: 2.5
Global: G2

27) Give the value of *l* for a 3p sublevel.
A) 1
B) -4
C) -1
D) 3
E) -3
Answer: A
Diff: 1 Var: 12 Page Ref: 2.5
LO: 2.5
Global: G2

28) Identify the correct values for a 1s sublevel.
A) $n = 3, l = 1, ml = 0$
B) $n = 2, l = 1, ml = -2$
C) $n = 1, l = 0, ml = 0$
D) $n = 2, l = 0, ml = 1$
E) $n = 4, l = -1, ml = -2$
Answer: C
Diff: 1 Var: 15 Page Ref: 2.5
LO: 2.5
Global: G2

29) Identify the correct values for a 2p sublevel.
A) $n = 3, l = 1, ml = 0$
B) $n = 2, l = 1, ml = +2$
C) $n = 1, l = 0, ml = 0$
D) $n = 2, l = 1, ml = 0$
E) $n = 4, l = -1, ml = +2$
Answer: D
Diff: 1 Var: 10 Page Ref: 2.5
LO: 2.5
Global: G2

30) Identify the correct values for a 3p sublevel.
A) $n = 3, l = 1, ml = 0$
B) $n = 2, l = 1, ml = +2$
C) $n = 1, l = 0, ml = 0$
D) $n = 2, l = 0, ml = 0$
E) $n = 4, l = -1, ml = 0$
Answer: A
Diff: 1 Var: 25 Page Ref: 2.5
LO: 2.5
Global: G2

31) Identify the correct values for a 4f sublevel.
A) $n = 3, l = 2, ml = 1$
B) $n = 2, l = 1, ml = 2$
C) $n = 1, l = 0, ml = 0$
D) $n = 2, l = 0, ml = 0$
E) $n = 4, l = 3, ml = -2$
Answer: E
Diff: 1 Var: 30 Page Ref: 2.5
LO: 2.5
Global: G2

32) In which orbital below would an electron (on average) be closest to the nucleus?
A) 2p
B) 4s
C) 2s
D) 5d
E) 3p
Answer: C
Diff: 1 Var: 8 Page Ref: 2.5
LO: 2.5
Global: G2

33) In which orbital below would an electron (on average) be farthest from the nucleus? A) 1s
B) 5f
C) 3s
D) 3d
E) 2p
Answer: B
Diff: 1 Var: 8 Page Ref: 2.5 LO: 2.5
Global: G2

34) How many subshells are there in the shell with $n = 2$?
A) 1
B) 2
C) 3
D) 4
Answer: B
Diff: 1 Var: 5 Page Ref: 2.5
LO: 2.5
Global: G2

35) What are the possible values of l if $n = 2$?
A) 2
B) 0 or 1
C) -4, -3, -2, -1, 0, +1, +2, +3, or +4
D) -5, -4, -3, -2, -1, 0, +1, +2, +3, +4, or +5
Answer: B
Diff: 1 Var: 5 Page Ref: 2.5
LO: 2.5
Global: G2

36) How many orbitals are there in the seventh shell?
A) 6
B) 7
C) 21
D) 49
Answer: D
Diff: 1 Var: 5 Page Ref: 2.5
LO: 2.5
Global: G2

37) Each of the following sets of quantum numbers is supposed to specify an orbital. Which of the following sets of quantum numbers contains an error?
A) $n = 2$, $l = 1$, $ml = +1$
B) $n = 4$, $l = 2$, $ml = +1$
C) $n = 3$, $l = 3$, $ml = -2$
D) $n = 1$, $l = 0$, $ml = 0$
E) $n = 3$, $l = 0$, $ml = 0$
Answer: C
Diff: 1 Var: 9 Page Ref: 2.5
LO: 2.5
Global: G2

38) Each of the following sets of quantum numbers is supposed to specify an orbital. Choose the one set of quantum numbers that does NOT contain an error.
A) $n = 2$, $l = 2$, $ml = +1$

B) $n = 2, l = -1, ml = 0$

C) $n = 3, l = 2, ml = +3$

D) $n = 4, l = 3, ml = -2$

E) $n = 4, l = 2, ml = +4$

Answer: D
Diff: 1 Var: 8 Page Ref: 2.5
LO: 2.5
Global: G2

39) Each of the following sets of quantum numbers is supposed to specify an orbital. Choose the one set of quantum numbers that does NOT contain an error.

A) $n = 4, l = 4, ml = 0$

B) $n = 3, l = 2, ml = -3$

C) $n = 4, l = 0, ml = +1$

D) $n = 3, l = 1, ml = -2$

E) $n = 5, l = 3, ml = -3$

Answer: E
Diff: 1 Var: 8 Page Ref: 2.5
LO: 2.5
Global: G2

40) How many different values of *ml* are possible in the 6f sublevel?

A) 1
B) 7
C) 4
D) 6
E) 2
Answer: B
Diff: 1 Var: 12 Page Ref: 2.5
LO: 2.5
Global: G2

41) For a hydrogen atom, which electronic transition would result in the **emission** of a photon with the highest energy?

A) $1s \rightarrow 2p$

B) $3p \rightarrow 7d$

C) $3p \rightarrow 1s$

D) $6f \rightarrow 4d$

Answer: C
Diff: 2 Var: 5 Page Ref: 2.5
LO: 2.6
Global: G2

42) For hydrogen, what is the wavelength of the photon emitted when an electron drops from a 4*d* orbital to a 2*s* orbital in a hydrogen atom? The Rydberg constant is 1.097 × 10-2 nm-1.
A) 656.3 nm
B) 486.2 nm
C) 364.6 nm
D) 2.057 × 10-3 nm
Answer: B
Diff: 3 Var: 5 Page Ref: 2.5
LO: 2.6
Global: G4

43) Choose the one set of quantum numbers that contains an error.
A) $n = 6$, $l = 3$, $ml = +2$
B) $n = 3$, $l = 2$, $ml = 0$
C) $n = 4$, $l = 0$, $ml = -3$
D) $n = 5$, $l = 4$, $ml = -2$
E) $n = 3$, $l = 1$, $ml = -1$
Answer: C
Diff: 1 Var: 50+ Page Ref: 2.5
LO: 2.5
Global: G2

44) In which orbital would an electron (on average) be closest to the nucleus?
A) 3p
B) 6f
C) 3s
D) 3d
E) 6d
Answer: C
Diff: 1 Var: 16 Page Ref: 2.5
LO: 2.5
Global: G2

45) Choose the transition (in a hydrogen atom) below that represents the **emission** of the shortest wavelength photon.
A) $n = 4$ to $n = 3$
B) $n = 1$ to $n = 2$
C) $n = 3$ to $n = 7$
D) $n = 8$ to $n = 12$
E) $n = 3$ to $n = 1$
Answer: E
Diff: 1 Var: 9 Page Ref: 2.5

Global: G2

46) Calculate the frequency of the light emitted a photon with a wavelength of 120 nm.
A) 1.03 × 1015 s-1
B) 2.50 × 1015 s-1
C) 5.38 × 1015s-1
D) 2.36 × 1015 s-1
E) 7.42 × 1015 s-1
Answer: B
Diff: 2 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G4

47) Calculate the wavelength (in nm) of the light emitted by a neon sign with a frequency of 4.60 × 1014 Hz.
A) 651 nm
B) 1254 nm
C) 730 nm
D) 339 nm E) 440 nm
Answer: A
Diff: 2 Var: 5 Page Ref: 2.2
LO: 2.1
Global: G4

2.3 Matching Questions

Match the following.

A) 7460 nm
B) 657 nm
C) 122 nm
D) 1280 nm
E) 103 nm

1) $n = 1$ to $n = 2$
Diff: 3 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G4

2) $n = 3$ to $n = 1$
Diff: 3 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G4

3) $n = 2$ to $n = 3$
Diff: 3 Var: 1 Page Ref: 2.5

LO: 2.5
Global: G4

4) $n = 6$ to $n = 5$
Diff: 3 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G4

5) $n = 5$ to $n = 3$
Diff: 3 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G4

Answers: 1) C 2) E 3) B 4) A 5) D

2.4 Short Answer Questions

1) Define diffraction.
Answer: When a wave encounters an obstacle or a slit that is comparable in size to its wavelength, it bends around or through it.
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1, G8

2) Define constructive interference.
Answer: Waves that are in phase combine with each other.
Diff: 1 Var: 1 Page Ref: 2.2
Global: G1, G8

3) What is the photoelectric effect?
Answer: Many metals emit electrons when light of high enough energy is shone on them. This observation brought the classical view of light into question. Diff: 1 Var: 1 Page Ref: 2.2
Global: G1, G8

4) Why do atoms only emit certain wavelengths of light when they are excited? (Why do line spectra exist?)
Answer: The energies of atoms are quantized. When an electron moves from one energy level to another during emission, a specific wavelength of light (with specific energy) is emitted. The electrons are not allowed "in between" quantized energy levels and thus only specific lines are observed.
Diff: 1 Var: 1 Page Ref: 2.3
Global: G8

5) Describe how a neon light works.
Answer: A neon sign contains glass tubes filled with neon gas. When an electric current is passed through the tube, the neon atoms absorb some of the energy and re-emits it as light. Diff: 1 Var: 1 Page Ref: 2.3

Global: G8

6) Why don't we observe the wavelength of everyday macroscopic objects?
Answer: Due to the large mass of macroscopic objects, the de Broglie wavelength is extremely small. The wavelength is so small that it is impossible to detect compared to the size of the object.
Diff: 1 Var: 1 Page Ref: 2.4
Global: G8

7) How many orbitals are contained in the $n = 2$ level? Give the l and ml values of each of them. Answer: Four: the 2s and three 2p orbitals.
2s, $l = 0$, $ml = 0$; 2p, $l = 1$, $ml = -1$ and $l = 1$, $ml = 0$ and $l = 1$, $ml = +1$.
Diff: 1 Var: 1 Page Ref: 2.5
LO: 2.5
Global: G2

8) Consider a 3p orbital. How is it different from a 2p orbital?
Answer: It is larger in size and contain additional nodes. Diff: 1 Var: 1 Page Ref: 2.6
LO: 2.5
Global: G8

9) Give an example of a d orbital.
Answer: d*yz*, d*xy*, d*xz*, d*x2-y2*, or d*z2*
Diff: 1 Var: 1 Page Ref: 2.6
LO: 2.5
Global: G2

10) Give an example of a p orbital.
Answer: p*x*, p*y*, or p*z*
Diff: 1 Var: 1 Page Ref: 2.6
LO: 2.5
Global: G2