***Physics: Principle and Applications*, 7e (Giancoli)**
Chapter 28 Quantum Mechanics of Atoms

28.1 Conceptual Questions

1) If the maximum possible accuracy in measuring the position of a particle increases, the maximum possible accuracy in measuring its velocity will
A) increase.
B) decrease.
C) not be affected.
Answer: B
Var: 1

2) If the maximum possible accuracy in measuring the velocity of a particle increases, the maximum possible accuracy in measuring its position will
A) increase.
B) decrease.
C) not be affected.
Answer: B
Var: 1

3) If the maximum possible accuracy in measuring the energy of a particle increases, the maximum possible accuracy in measuring its lifetime will
A) increase.
B) decrease.
C) not be affected.
Answer: B
Var: 1

4) If the maximum possible accuracy in measuring the lifetime of a particle increases, the maximum possible accuracy in measuring its energy will
A) increase.
B) decrease.
C) not be affected.
Answer: B
Var: 1

5) A hydrogen atom is in the 6*h* state. What is the principal quantum number.
A) 0
B) 3
C) 5
D) 6
E) 7
Answer: D
Var: 1

6) The orbital angular momentum quantum number can take which of the following values for any given value of the principal quantum number, n?
A) $\ell = 0, 1, 2, \ldots$
B) $\ell = 0, 1, 2, \ldots, n$
C) $\ell = 0, 1, 2, \ldots, (n - 1)$
D) $\ell = 1, 2, 3, 4, \ldots$
E) $\ell = 1, 2, 3, 4, \ldots, (n + 1)$
Answer: C
Var: 1

7) Which of the following values can be taken by the electron spin quantum number, m_S?
A) $\pm 1/2$
B) 0
C) ± 1
D) ± 2
E) ± 3
Answer: A
Var: 1

8) According to the quantum mechanical model of the hydrogen atom, if the orbital angular momentum quantum number is ℓ, there will be how many permitted magnetic quantum numbers?
A) $\ell/2$
B) 2ℓ
C) $2\ell + 1$
D) $2\ell - 1$
E) 3ℓ
Answer: C
Var: 1

9) According to the quantum mechanical model of the hydrogen atom, if the principal quantum number is n, how many different orbital angular momentum quantum numbers are permitted?
A) $n/2$
B) n
C) $2n$
D) $3n$
E) $4n$
Answer: B
Var: 1

10) According to Pauli's exclusion principle, how many electrons in an atom may have a particular set of quantum numbers?
A) 1
B) 3
C) 2
D) 4
E) 5
Answer: A
Var: 1

11) The principal quantum number *n* can have any integer value ranging from
A) -∞ to +∞.
B) 0 to ∞.
C) 1 to ∞.
D) 1 to 100.
Answer: C
Var: 1

12) The orbital angular momentum quantum number ℓ can have any integer value ranging from
A) 0 to *n*.
B) 0 to (*n*-1).
C) 1 to *n*.
D) 1 to (*n*+1).
E) -*n* to *n*.
Answer: B
Var: 1

13) The magnetic quantum number m_1 can have any integer value ranging from
A) -*n* to +*n*.
B) -ℓ to +ℓ.
C) 0 to *n*.
D) 0 to ℓ.
E) 0 to (*n*-1)
Answer: B
Var: 1

14) The electron spin quantum number can have values of
A) -1/2, -1, 0, +1, +1/2.
B) -1/2, -1, +1, +1/2.
C) -1/2, 0, +1/2.
D) -1/2, +1/2.
E) only +1/2.
Answer: D
Var: 1

15) What is the atomic number of a neutral atom that has an electron configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$?
A) 5
B) 11
C) 14
D) 20
Answer: C
Var: 1

16) If $\ell = 4$, which one of the following is a possible quantum number for n?
A) 0
B) 2
C) 3
D) 4
E) 8
Answer: E
Var: 1

17) If $n = 5$, which one of the following is *not* an allowed magnetic quantum number m_1?
A) 0
B) 2
C) 4
D) 5
Answer: D
Var: 1

18) In its ground state, the quantum numbers (n, ℓ, m_1, m_s) for hydrogen are, respectively,
A) 1, 1, 1, 1.
B) 1, 0, 0, 0.
C) 1, 0, 0, ±1/2.
D) 1, 1, 1, ±1/2.
Answer: C
Var: 1

19) Consider ground-state helium having two electrons in orbit. If one of the electrons has quantum numbers (n, ℓl, m_1, m_s) of 1, 0, 0, -1/2 respectively, the quantum numbers for the other electron will be
A) 1, 1, 0, -1/2.
B) 1, 0, 0, +1/2.
C) 1, 1, 1, +1/2.
D) none of the given answers.
Answer: B
Var: 1

20) The elements in the periodic table that have completely filled shells or subshells are referred to as
A) noble gases.
B) halogens.
C) alkali metals.
D) transition elements.
Answer: A
Var: 1

28.2 Problems

1) A tiny dust particle of mass 8.50 μg is being observed under a microscope. Its position is determined to be within a space of 0.0060 mm. ($h = 6.626 \times 10^{-34}$ J · s)
(a) Find the uncertainty in its speed implied by the uncertainty in its position.
(b) Assuming the dust particle is moving at the speed in part (a), how many years would it take for the particle to move 1.0 mm?
Answer: (a) 2.1×10^{-21} m/s (b) 1.5×10^{10} y
Var: 1

2) If an electron is determined to be at $x = 2.000$ cm ± 0.0010 cm, what is the minimum uncertainty in the x component of its velocity? ($m_{\text{electron}} = 9.11 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ J · s)
Answer: 5.8 m/s
Var: 1

3) Suppose that the speed of an electron traveling 1.0 km/s is known to an accuracy of 1 part in 10,000 (that is, within 0.01%). What is the minimum uncertainty in the position of this electron? ($m_{\text{electron}} = 9.11 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ J · s)
Answer: 1.2 mm
Var: 1

4) A molecule of roughly spherical shape has a mass of 1.80×10^{-25} kg and a diameter of 0.6 nm. If the uncertainty in the measured position of the molecule is equal to the molecular diameter, what is the minimum uncertainty in the speed of the molecule? ($h = 6.626 \times 10^{-34}$ J · s)
A) 1 m/s
B) 10 m/s
C) 100 m/s
D) 0.1 m/s
E) 0.01 m/s
Answer: A
Var: 1

5) A 10-g bouncy ball is confined in a 8.3-cm-long box. What is its minimum energy? (h = 6.626 × 10^{-34} J · s)
A) 8.1 × 10^{-65} J
B) 3.2 × 10^{-46} J
C) 1.3 × 10^{-20} J
D) 9.4 × 10^{-75} J
Answer: A
Var: 1

6) If the uncertainty in the position of a proton is 0.053 nm, what is the uncertainty in its speed? (h = 6.626 × 10^{-34} J · s, m_{proton} = 1.67 × 10^{-27} kg)
A) 2.2 m/s
B) 0.60 km/s
C) 0.98 km/s
D) 37 m/s
E) 1.2 km/s
Answer: E
Var: 1

7) If you confine an electron to a box and know that the uncertainty in the electron's speed is 65 m/s, what is the smallest length that the box could have? (m_{electron} = 9.11 × 10^{-31} kg, h = 6.626 × 10^{-34} J · s)
A) 1.1 × 10^{-5} m
B) 1.8 × 10^{-6} m
C) 5.8 × 10^{-6} m
D) 1.8 × 10^{-5} m
E) 8.4 × 10^{-6} m
Answer: B
Var: 1

8) What is the minimum uncertainty in determining the position of an electron if the speed of the electron is 6.0 km/s within an accuracy of 0.0040%? (m_{electron} = 9.11 × 10^{-31} kg, h = 6.626 × 10^{-34} J · s)
A) 0.11 mm
B) 0.15 mm
C) 0.24 mm
D) 0.34 mm
E) 0.48 mm
Answer: E
Var: 1

9) An electron inside a hydrogen atom is confined to within a space of about 0.12 nm. What is the uncertainty in this electron's speed? ($m_{\text{electron}} = 9.11 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ J · s)
A) 3.1×10^{5} m/s
B) 4.8 m/s
C) 3.1 km/s
D) 9.6×10^{5} m/s
E) 4.8×10^{6} m/s
Answer: D
Var: 1

10) Suppose that the speed of an electron traveling 2.0 km/s is known to an accuracy of 1 part in 10^{5} (i.e., within 0.0010%). What is the least possible uncertainty within which we can determine the position of this electron? ($m_{\text{electron}} = 9.11 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ J · s)
A) 2.0 mm
B) 5.8 mm
C) 14 mm
D) 14 cm
E) 8.5 nm
Answer: B
Var: 1

11) A measurement of an electron's speed is 2.0×10^{6} m/s and has an uncertainty of 10%. What is the minimum uncertainty in the position of the electron? ($m_{\text{electron}} = 9.11 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ J · s)
A) 0.29 nm
B) 0.58 nm
C) 0.87 nm
D) 1.5 nm
E) 4.9 nm
Answer: B
Var: 1

12) A baseball has mass 143 g and a speed of 45 m/s, with the speed known to within 0.10%. What is the minimum uncertainty in the position of the baseball? ($h = 6.626 \times 10^{-34}$ J · s)
A) 1.4×10^{-32} m
B) 1.6×10^{-32} m
C) 1.4×10^{-30} m
D) 1.6×10^{-30} m
E) 1.8 nm
Answer: B
Var: 1

13) An electron is known to be confined to a region of width 0.10 nm. What is an approximate value for the least kinetic energy it could have, in electron-volts? ($h = 6.626 \times 10^{-34}$ J · s, 1 eV = 1.60×10^{-19} J, ($m_{\text{electron}} = 9.11 \times 10^{-31}$ kg)
A) 1.1 eV
B) 0.88 eV
C) 3.8 eV
D) 8.8 eV
E) 17 eV
Answer: C
Var: 1

14) The radius of a typical nucleus is about 5×10^{-15} m. Assuming this to be the uncertainty in the position of a proton in the nucleus, estimate the uncertainty in the proton's energy, in MeV. ($m_{\text{proton}} = 1.67 \times 10^{-27}$ kg, $h = 6.626 \times 10^{-34}$ J · s, 1 eV = 1.6×10^{-19} J)
A) 0.4 MeV
B) 0.6 MeV
C) 0.8 MeV
D) 1.0 MeV
Answer: C
Var: 1

15) An electron is trapped in a quantum well that is 48.6 nm wide. Calculate the minimum uncertainty in its velocity. ($h = 6.626 \times 10^{-34}$ J · s, $m_{\text{electron}} = 9.11 \times 10^{-31}$ kg)
A) 7.49×10^{3} m/s
B) 1.79×10^{4} m/s
C) 2.38×10^{3} m/s
D) 3.34×10^{4} m/s
E) 1.01×10^{3} m/s
Answer: C
Var: 1

16) You measure the velocity of an electron to an accuracy of ±22.6 m/s. What is the minimum uncertainty in its position? ($h = 6.626 \times 10^{-34}$ J · s, $m_{\text{electron}} = 9.11 \times 10^{-31}$ kg)
A) 8.05 μm
B) 4.03 μm
C) 16.1 μm
D) 32.2 μm
E) 5.12 μm
Answer: E
Var: 1

17) An unstable particle produced in a high-energy collision is measured to have an energy of 483 MeV and an uncertainty in energy of 29 keV. Use the Heisenberg uncertainty principle to estimate the lifetime of this particle. ($h = 6.626 \times 10^{-34}$ J · s, 1 eV = 1.60×10^{-19})
Answer: 2.3×10^{-20} s
Var: 1

18) The excited state of a certain atom is 3.2 eV ± 0.21 eV. ($h = 6.626 \times 10^{-34}$ J · s, 1eV = 1.60×10^{-19} J)
(a) What is the average lifetime of this state, in femtoseconds?
(b) If the excited energy were doubled (to 6.4 eV ± 0.21 eV), how would the lifetime be affected?
Answer: (a) 3.1 fs (b) unchanged since the uncertainty is still ± 0.21 eV
Var: 1

19) A laser produces a beam of 4000-nm light. A shutter allows a pulse of light, 30 ps in duration, to pass through. What is the uncertainty in the energy of a photon in the pulse? (1 eV = 1.60×10^{-19} J, $h = 6.626 \times 10^{-34}$ J · s)
A) 2×10^{-6} eV
B) 2×10^{-5} eV
C) 2×10^{-4} eV
D) 2×10^{-3} eV
E) 2×10^{-2} eV
Answer: B
Var: 1

20) The energy released when an unstable electron state decays has an uncertainty of about 0.50 eV. What is the uncertainty in the life-time of the level? ($h = 6.626 \times 10^{-34}$ J · s, 1 eV = 1.60×10^{-19} J)
A) 1.3×10^{-15} s
B) 8.3×10^{-15} s
C) 1.3×10^{-11} s
D) 8.3×10^{-11} s
Answer: A
Var: 1

21) For an electron in the M ($n = 3$) shell, find (a) the largest possible orbital angular momentum it can have, and (b) the smallest possible orbital angular momentum it can have. Express your answers in SI units, and for each case indicate the subshell (*s*, *p*, *d*, ...) of the electron. ($h = 6.626 \times 10^{-34}$ J · s)
Answer: (a) 2.583×10^{-34} kg · m^2/s, *d* subshell, (b) 0 kg · m^2/s, *s* subshell
Var: 1

22) An atom has completely filled inner shells and a single valence electron in an excited p state. The filled inner shells have an orbital momentum equal to zero. What is the magnitude of the orbital angular momentum of the atom?

A) 1.0 $\frac{h}{2\pi}$

B) 1.2 $\frac{h}{2\pi}$

C) 1.4 $\frac{h}{2\pi}$

D) 1.7 $\frac{h}{2\pi}$

E) 2.0 $\frac{h}{2\pi}$

Answer: C
Var: 1

23) What is the greatest magnitude of the orbital angular momentum *L* that you can find in a state with $n = 6$?

A) 5.48 $\frac{h}{2\pi}$

B) 5.92 $\frac{h}{2\pi}$

C) 6 $\frac{h}{2\pi}$

D) 6.48 $\frac{h}{2\pi}$

Answer: A
Var: 5

24) In an excited hydrogen atom, the electron is in the 4*d* state. If this atom is in an external magnetic field, what are the smallest and largest possible angles between the orbital angular momentum and the direction of the magnetic field (or any other direction, for that matter)?
Answer: 35.3°, 145°
Var: 1

25) An atom has completely filled inner shells and a single valence electron in an excited p state. The filled inner shells have an orbital momentum equal to zero. When a magnetic field is applied, what are the possible angles between the magnetic field and the orbital angular momentum?
A) 45°
B) 90°
C) 45°, 90°
D) 45°, 135°
E) 45°, 90°, 135°
Answer: E
Var: 1

26) What is the minimum angle between the *z*-axis (or any other axis you choose) and the orbital angular momentum of an electron in the $n = 4$ state?
A) 30.0°
B) 41.4°
C) 60.0°
D) 45.0°
Answer: A
Var: 3

27) Consider the $n = 10$ shell.
(a) What is the largest value of the angular momentum quantum number, ℓ, in this shell?
(b) How many electrons can be placed in this shell?
Answer: (a) 9 (b) 200
Var: 9

28) An atom with atomic number 6 is in its ground state. How many electrons are in its outermost shell?
Answer: 4
Var: 8

29) Write out the electron configuration for the ground state of the phosphorus atom, which has 15 electrons.
Answer: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
Var: 1

30) The only valid electron state and shell designation among the following is
A) 1*p*, K ($n = 1$) shell.
B) 2*s*, K ($n = 1$) shell.
C) 1*s*, L ($n = 2$) shell.
D) 2*p*, L ($n = 2$) shell.
E) 3*f*, M ($n = 3$) shell.
Answer: D
Var: 1

31) The only invalid electron state and shell designation among the following is
A) 1*s*, K (*n* = 1) shell.
B) 2*s*, L (*n* = 2) shell.
C) 2*d*, L (*n* = 2) shell.
D) 3*s*, M (*n* = 3) shell.
E) 3*d*, M (*n* = 3) shell.
Answer: C
Var: 1

32) What is the electron configuration for Li, which has 3 electrons?
A) $1s^3$
B) $1s^1\ 2s^2$
C) $1s^2\ 2s^1$
D) $1s^2\ 1p^1$
E) $1s^1\ 2s^1\ 3s^1$
Answer: C
Var: 1

33) What is the correct ground state electron configuration of boron, which has 5 electrons?
A) $1s^2\ 2s^2\ 2p$
B) $1s^2\ 2s^2\ 2p^3$
C) $1s^2\ 1p^2\ 2s$
D) $1s^2\ 2p^2\ 3s$
E) $1s^2\ 2p^3$
Answer: A
Var: 1

34) Which one of the following is the correct electronic configuration for carbon, which has 6 electrons?
A) $1s^2\ 2s^2\ 2p^2$
B) $1s^1\ 2p^1$
C) $1s^1\ 2s^2\ 2p^1$
D) $1s^1\ 2s^1\ 2p^1$
E) $1s^2\ 2s^2\ 2p^4$
Answer: A
Var: 1

35) Which one of the following is the correct electronic configuration for the sodium atom, which has 11 electrons?
A) $1s^1\ 2s^2\ 3p^6\ 2s^2$
B) $1s^2\ 2s^1\ 3p^6\ 2s^2$
C) $1s^1\ 2s^2\ 2p^6\ 2s^2$
D) $1s^2\ 2s^2\ 2p^6\ 3s^2$
E) $1s^2\ 2s^2\ 2p^6\ 3s^1$
Answer: E
Var: 1

36) A hydrogen atom is in the 6*h* state. How many electrons are allowed in this state?
A) 22
B) 18
C) 14
D) 10
E) 6
Answer: A
Var: 1

37) A hydrogen atom is in the 6*h* state. Which one of the following numbers could be an orbital angular momentum quantum number ℓ for that state?
A) 5
B) 6
C) 7
D) 8
E) 9
Answer: A
Var: 1

38) A hydrogen atom is in the 6*h* state. Which one of the following is *not* a magnetic quantum number for that state?
A) 0
B) 1
C) 2
D) 4
E) 6
Answer: E
Var: 1

39) In a hydrogen atom, a given electron has $n = 7$. How many possible values can ℓ have?
A) 6
B) 7
C) 15
D) 98
Answer: B
Var: 1

40) In a hydrogen atom, a given electron has $\ell = 7$. How many possible values can m_1 have?
A) 6
B) 7
C) 15
D) 98
Answer: C
Var: 1

41) In a hydrogen atom, an electron with $n = 7$ can exist in how many different quantum states?
A) 6
B) 7
C) 15
D) 98
Answer: D
Var: 1

42) How many values of the magnetic quantum number, m_ℓ, are possible if the orbital angular momentum quantum number is $\ell = 2$?
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: E
Var: 1

43) How many values of the magnetic quantum number, m_ℓ, correspond to a value of $\ell = 4$?
A) 3
B) 5
C) 8
D) 9
E) 7
Answer: D
Var: 1

44) For the ground state of the hydrogen atom, which of the following numbers represents the correct value of the orbital angular momentum quantum number?
A) -1
B) 1
C) 0
D) 2
E) -2
Answer: C
Var: 1

45) For the ground state of the hydrogen atom, which of the following numbers represents the correct value of the magnetic quantum number?
A) -1
B) 0
C) 1
D) 2
E) -2
Answer: B
Var: 1

46) How many values can the magnetic quantum number have in a hydrogen atom for which the orbital angular momentum quantum number is equal to 8?
A) 9
B) 15
C) 5
D) 8
E) 17
Answer: E
Var: 1

47) How many *unique* quantum states correspond to the lowest possible energy level of an electron in the hydrogen atom?
A) 3
B) 0
C) 1
D) 4
E) 2
Answer: E
Var: 1

48) How many electrons can be found with principal quantum number $n = 3$ in a suitably heavy atom?
A) 18
B) 6
C) 20
D) 9
Answer: A
Var: 3

49) How many 2*d* electron states can an atom have?
A) 0
B) 4
C) 6
D) 8
E) 10
Answer: A
Var: 1

50) How many 3*d* electron states can an atom have?
A) 0
B) 4
C) 6
D) 8
E) 10
Answer: E
Var: 1

51) What is the maximum number of electrons that can occupy the *g* subshell?
A) 10
B) 14
C) 18
D) 22
Answer: C
Var: 3

52) How many possible sets of electron states (or quantum numbers) are there in the 5*f* subshell?
A) 2
B) 8
C) 10
D) 14
Answer: D
Var: 1

53) How many electrons will fit into a 4*f* subshell?
A) 3
B) 4
C) 7
D) 14
Answer: D
Var: 1

54) The values of n and ℓ for a 4*f* subshell are
A) $n = 4$, $\ell = 4$.
B) $n = 4$, $\ell = 3$.
C) $n = 3$, $\ell = 3$.
D) $n = 4$, $\ell = 2$.
E) $n = 3$, $\ell = -3$.
Answer: B
Var: 1

55) Neon has 10 electrons. What is the value of *Z* of the next higher element that has chemical properties very similar to those of neon?
A) 11
B) 17
C) 18
D) 19
E) 36
Answer: C
Var: 1