# *Organic Chemistry - A Tenth Edition 10th edition McMurry Test Bank*

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# Organic Chemistry

ISBN 9781711471853 | Chapter 1: Structure and Bonding

*Total Questions: 100*

## Multiple Choice

**Q1.**
What is the modern defining characteristic of an organic compound?

**A) It contains carbon ✓ Correct**
**B)** It is isolated from living organisms
**C)** It has a low melting point
**D)** It is insoluble in water

*Rationale: Modern organic chemistry is defined as the study of carbon compounds.*

**Q2.**
Which subatomic particles are found in the atomic nucleus?

**A)** Electrons and protons
**B) Protons and neutrons ✓ Correct**
**C)** Electrons and neutrons
**D)** Only protons

*Rationale: The nucleus contains positively charged protons and neutral neutrons.*

**Q3.**
For a neutral atom, the number of electrons is equal to the number of which particles?

**A)** Neutrons
**B)** Orbitals
**C) Protons ✓ Correct**
**D)** Isotopes

*Rationale: A neutral atom has equal numbers of positively charged protons and negatively charged electrons.*

**Q4.**
What does the atomic number (Z) specify?

**A)** The total number of protons and neutrons
**B)** The number of neutrons only
**C) The number of protons in the nucleus ✓ Correct**
**D)** The number of valence electrons only

*Rationale: Atomic number is defined by the number of protons in the nucleus.*

**Q5.**

What does the mass number (A) represent?

**A)** The weighted average of isotopes
**B) The total number of protons and neutrons ✓ Correct**
**C)** The number of electrons in the valence shell
**D)** The number of protons only

*Rationale: Mass number equals the sum of protons and neutrons in the nucleus.*

**Q6.**

Atoms with the same atomic number but different mass numbers are called what?

**A)** Ions
**B)** Allotropes
**C)** Isomers
**D) Isotopes ✓ Correct**

*Rationale: Isotopes are atoms of the same element that differ in neutron number and therefore mass number.*

**Q7.**

What is atomic weight?

**A)** The mass number of the most abundant isotope
**B) The weighted average of naturally occurring isotopes ✓ Correct**
**C)** The total number of nucleons divided by two
**D)** The mass of one mole of atoms in grams only

*Rationale: Atomic weight is the weighted average mass of an element's naturally occurring isotopes.*

**Q8.**

Which unit is defined as one twelfth the mass of one atom of carbon-12?

**A)** Picometer
**B)** Angstrom
**C) Dalton ✓ Correct**
**D)** Mole

*Rationale: One dalton, or unified atomic mass unit, is defined relative to carbon-12 in this way.*

**Q9.**

An orbital is best defined as what?

**A)** A fixed circular path of an electron
**B) A region of space where an electron is most likely to be found ✓ Correct**
**C)** The exact location of an electron at one moment
**D)** A shell containing only paired electrons

*Rationale: An orbital describes the volume of space around a nucleus where an electron is most likely to be found.*

**Q10.**

Which type of orbital has a spherical shape?

**A)** p orbital
**B)** d orbital
**C)** f orbital
**D) s orbital ✓ Correct**

*Rationale: s orbitals are spherical with the nucleus at the center.*

**Q11.**

Which type of orbital is described as dumbbell-shaped?

**A)** s orbital
**B) p orbital ✓ Correct**
**C)** d orbital
**D)** f orbital

*Rationale: p orbitals have two lobes and a dumbbell-like shape.*

**Q12.**

How many electrons can occupy a single orbital?

**A)** 1
**B) 2 ✓ Correct**
**C)** 4
**D)** 8

*Rationale: Each orbital can hold a maximum of two electrons with opposite spins.*

**Q13.**

How many electrons can the second electron shell hold?

**A)** 2
**B)** 6
**C) 8 ✓ Correct**
**D)** 18

*Rationale: The second shell contains one 2s and three 2p orbitals for a total of 8 electrons.*

**Q14.**

What is a node in a p orbital?

**A)** A region of maximum electron density
**B)** A point containing the nucleus only
**C) A region of zero electron density ✓ Correct**
**D)** A shared pair of electrons

*Rationale: A node is a region where the probability of finding an electron is zero.*

**Q15.**

The three p orbitals within a shell are oriented how relative to one another?

**A)** Parallel
**B)** At 60° angles
**C) Mutually perpendicular ✓ Correct**
**D)** In a single plane

*Rationale: The three p orbitals are oriented along perpendicular x, y, and z axes.*

**Q16.**

Which principle states that the lowest-energy orbitals fill first?

**A)** Hund's rule
**B)** Pauli exclusion principle
**C) Aufbau principle ✓ Correct**
**D)** Octet rule

*Rationale: The Aufbau principle states that electrons occupy lower-energy orbitals before higher-energy ones.*

**Q17.**

Which principle states that two electrons in the same orbital must have opposite spins?

**A) Pauli exclusion principle ✓ Correct**
**B)** Hund's rule
**C)** Aufbau principle
**D)** Valence bond theory

*Rationale: The Pauli exclusion principle requires paired electrons in one orbital to have opposite spins.*

**Q18.**

Which rule states that electrons occupy equal-energy orbitals singly with parallel spins before pairing?

**A)** Aufbau principle
**B) Hund's rule ✓ Correct**
**C)** Octet rule
**D)** Lewis rule

*Rationale: Hund's rule describes single occupation of degenerate orbitals before electron pairing occurs.*

**Q19.**

What is the ground-state electron configuration?

**A)** The electron arrangement in an excited atom
**B)** The highest-energy arrangement of electrons
**C) The lowest-energy arrangement of electrons in an atom ✓ Correct**
**D)** The arrangement of electrons in a molecule only

*Rationale: Ground-state electron configuration refers to the atom's lowest-energy electron arrangement.*

**Q20.**

Who proposed that carbon is tetravalent and can form chains in organic compounds?

**A)** Linus Pauling and G. N. Lewis
**B)** Jacobus van't Hoff and Joseph Le Bel
**C) August Kekulé and Archibald Couper ✓ Correct**
**D)** Niels Bohr and Erwin Schrödinger

*Rationale: Kekulé and Couper independently proposed carbon tetravalence and carbon chain formation.*

**Q21.**

Who proposed that the four bonds of carbon are directed toward the corners of a tetrahedron?

**A)** Kekulé and Couper
**B) van't Hoff and Le Bel ✓ Correct**
**C)** Lewis and Pauling
**D)** Hund and Pauli

*Rationale: van't Hoff and Le Bel introduced the three-dimensional tetrahedral arrangement of carbon bonds.*

**Q22.**

In a three-dimensional structural drawing, what does a dashed line represent?

**A)** A bond in the plane of the page
**B)** A bond coming out toward the viewer
**C) A bond going behind the plane of the page ✓ Correct**
**D)** A partial bond in resonance

*Rationale: A dashed bond indicates a bond receding behind the plane of the page.*

**Q23.**

Why do atoms form chemical bonds?

**A)** To increase atomic number
**B)** To become less stable
**C) To achieve a lower-energy, more stable state ✓ Correct**
**D)** To eliminate all lone pairs

*Rationale: Bond formation lowers the energy of the system and increases stability.*

**Q24.**

What is always true when a chemical bond forms?

**A)** Energy is absorbed
**B) Energy is released ✓ Correct**
**C)** Electrons are lost to the environment
**D)** The atoms become ions

*Rationale: Bond formation releases energy because the bonded state is lower in energy.*

**Q25.**

An ionic bond is best described as what?

**A)** A bond formed by sharing electrons equally
**B)** A bond formed by overlap of p orbitals only
**C) An attraction between oppositely charged ions ✓ Correct**
**D)** A bond involving only carbon atoms

*Rationale: Ionic bonds arise from electrostatic attraction between cations and anions.*

**Q26.**

A covalent bond is best described as what?

**A)** Transfer of electrons from one atom to another
**B) Sharing of an electron pair between atoms ✓ Correct**
**C)** Attraction between two noble gases
**D)** Repulsion between two nuclei

*Rationale: A covalent bond forms when atoms share electrons.*

**Q27.**

What is a molecule?

**A)** Any collection of ions in a crystal lattice
**B) A neutral collection of atoms held together by covalent bonds ✓ Correct**
**C)** Any substance containing carbon
**D)** A charged species with an incomplete octet

*Rationale: A molecule is a neutral assembly of atoms connected by covalent bonds.*

**Q28.**

In a Lewis structure, valence electrons are represented by what?

**A)** Arrows
**B)** Colors
**C) Dots ✓ Correct**
**D)** Triangles

*Rationale: Lewis structures use dots to represent valence-shell electrons.*

**Q29.**

What term describes valence electrons not used in bonding?

**A)** Core electrons
**B) Lone-pair electrons ✓ Correct**
**C)** Bonding pairs
**D)** Sigma electrons

*Rationale: Nonbonding valence electrons are called lone pairs.*

**Q30.**

How many covalent bonds does a neutral oxygen atom typically form in stable molecules?

**A)** 1
**B) 2 ✓ Correct**
**C)** 3
**D)** 4

*Rationale: Oxygen typically forms two covalent bonds to complete its octet.*

**Q31.**

According to valence bond theory, a covalent bond forms when what occurs?

**A)** A proton is transferred between atoms
**B)** Two filled orbitals repel each other
**C) Two singly occupied orbitals overlap and the electrons pair ✓ Correct**
**D)** A molecular orbital splits into atomic orbitals

*Rationale: VB theory describes bond formation as overlap of singly occupied orbitals with electron pairing.*

**Q32.**

A sigma (σ) bond is formed by what kind of overlap?

**A)** Sideways overlap of p orbitals
**B) Head-on overlap along the internuclear axis ✓ Correct**
**C)** Overlap of two antibonding orbitals
**D)** Overlap that creates a node between nuclei

*Rationale: Sigma bonds arise from head-on overlap along the line connecting the nuclei.*

**Q33.**

What is bond length?

**A)** The energy needed to break a bond
**B)** The angle between two bonds
**C) The optimum distance between bonded nuclei ✓ Correct**
**D)** The number of electrons in a bond

*Rationale: Bond length is the internuclear distance at minimum energy in a bonded pair.*

**Q34.**

What is bond strength?

**A)** The number of orbitals used in bonding
**B)** The energy released when a nucleus forms
**C) The energy required to break a bond ✓ Correct**
**D)** The charge separation in a bond

*Rationale: Bond strength corresponds to the energy needed to separate bonded atoms.*

**Q35.**

Which statement best describes the hybridization of carbon in methane?

**A) It uses four equivalent sp3 hybrid orbitals ✓ Correct**
**B)** It uses three sp2 orbitals and one p orbital
**C)** It uses two sp orbitals and two p orbitals
**D)** It uses only unhybridized s orbitals

*Rationale: Methane is explained by four equivalent sp3 hybrid orbitals on carbon.*

**Q36.**

What is the approximate H–C–H bond angle in methane?

**A)** 90°
**B) 109.5° ✓ Correct**
**C)** 120°
**D)** 180°

*Rationale: Methane has tetrahedral geometry with bond angles of about 109.5°.*

**Q37.**

The carbon–carbon bond in ethane is formed by overlap of which orbitals?

**A)** Two p orbitals only
**B)** Two sp2 orbitals only
**C) Two sp3 hybrid orbitals ✓ Correct**
**D)** One s and one p orbital

*Rationale: The C–C single bond in ethane is a sigma bond formed by sp3–sp3 overlap.*

**Q38.**

What type of hybridization is present on each carbon atom in ethylene?

**A)** sp3
**B) sp2 ✓ Correct**
**C)** sp
**D)** dsp3

*Rationale: Each carbon in ethylene is sp2-hybridized.*

**Q39.**

A carbon–carbon double bond consists of which combination of bonds?

**A) One σ bond and one π bond ✓ Correct**
**B)** Two σ bonds
**C)** Two π bonds
**D)** One ionic bond and one σ bond

*Rationale: A double bond contains one sigma bond and one pi bond.*

**Q40.**

In ethylene, the π bond is formed by what interaction?

**A)** Head-on overlap of sp2 orbitals
**B) Sideways overlap of unhybridized p orbitals ✓ Correct**
**C)** Transfer of electrons between carbons
**D)** Overlap of two s orbitals

*Rationale: The π bond in ethylene comes from sideways overlap of p orbitals.*

**Q41.**

What is the approximate geometry around each carbon atom in ethylene?

**A)** Tetrahedral
**B) Trigonal planar ✓ Correct**
**C)** Linear
**D)** Octahedral

*Rationale: sp2-hybridized carbons have trigonal planar geometry with angles near 120°.*

**Q42.**

What type of hybridization is present on each carbon atom in acetylene?

**A)** sp3
**B)** sp2
**C) sp ✓ Correct**
**D)** sp3d

*Rationale: Each carbon in acetylene is sp-hybridized.*

**Q43.**

A carbon–carbon triple bond consists of which combination of bonds?

**A)** One σ bond and one π bond
**B)** Three σ bonds
**C) One σ bond and two π bonds ✓ Correct**
**D)** Two σ bonds and one π bond

*Rationale: A triple bond contains one sigma bond and two pi bonds.*

**Q44.**

What is the bond angle around an sp-hybridized carbon atom, as in acetylene?

**A)** 90°
**B)** 109.5°
**C)** 120°
**D) 180° ✓ Correct**

*Rationale: sp hybridization produces a linear arrangement with 180° bond angles.*

**Q45.**

Which statement best describes the hybridization of nitrogen in methylamine?

**A)** Nitrogen is sp-hybridized with two lone pairs
**B)** Nitrogen is sp2-hybridized with no lone pair
**C) Nitrogen is sp3-hybridized with one lone pair ✓ Correct**
**D)** Nitrogen is unhybridized in a linear arrangement

*Rationale: Nitrogen in methylamine is described as sp3-hybridized and bears one lone pair.*

**Q46.**

Which statement best describes the hybridization of oxygen in methanol?

**A) Oxygen is sp3-hybridized with two lone pairs ✓ Correct**
**B)** Oxygen is sp2-hybridized with one lone pair
**C)** Oxygen is sp-hybridized with no lone pairs
**D)** Oxygen is unhybridized with four bonds

*Rationale: Oxygen in methanol is approximately sp3-hybridized and has two lone pairs.*

**Q47.**

In molecular orbital theory, a bonding molecular orbital results from what kind of combination?

**A)** Subtractive combination of atomic orbitals
**B) Additive combination of atomic orbitals ✓ Correct**
**C)** Combination of only core orbitals
**D)** Combination that always creates a node between nuclei

*Rationale: Bonding molecular orbitals arise from additive combination of atomic orbitals.*

**Q48.**

What feature characterizes an antibonding molecular orbital?

**A)** It is lower in energy than the parent atomic orbitals
**B)** It concentrates electron density between nuclei
**C) It contains a node between nuclei ✓ Correct**
**D)** It can hold only one electron

*Rationale: Antibonding molecular orbitals have a node between nuclei and are higher in energy.*

**Q49.**

Which statement is correct for a skeletal structure?

**A)** Every carbon atom and every hydrogen atom must be written explicitly
**B) Carbon atoms are assumed at line ends and intersections ✓ Correct**
**C)** Only heteroatoms are omitted
**D)** Lone pairs are always shown on carbon

*Rationale: In skeletal structures, carbon atoms are implied at line ends and junctions.*

**Q50.**

In a condensed structure, what is generally omitted from explicit drawing?

**A)** Only heteroatoms
**B)** Only multiple bonds
**C) Carbon–carbon and carbon–hydrogen single bonds ✓ Correct**
**D)** All lone pairs and all atoms

*Rationale: Condensed structures typically omit explicit C–C and C–H single bonds for brevity.*

**Q51.**

A pathology laboratory is evaluating a carbon-14 tracer used in a metabolic research protocol. Which statement best explains why carbon-14 is classified differently from carbon-12?

**A)** It has a different number of protons than carbon-12
**B) It has a different number of neutrons than carbon-12 ✓ Correct**
**C)** It has a different number of valence electrons than carbon-12
**D)** It has a different number of electron shells than carbon-12

*Rationale: Isotopes of the same element have the same atomic number but differ in neutron number, giving different mass numbers.*

**Q52.**

A pharmacist reviewing a molecular model of methane for a medicinal chemistry discussion asks why all four C–H bonds are equivalent. Which explanation is most accurate?

**A) Carbon uses four equivalent sp3 hybrid orbitals arranged tetrahedrally ✓ Correct**
**B)** Carbon uses one s orbital and three unhybridized p orbitals with identical energies
**C)** Carbon forms ionic bonds with hydrogen that average to the same length
**D)** Carbon alternates between single and double bonds to hydrogen very rapidly

*Rationale: Methane's four identical bonds arise from overlap of four equivalent tetrahedrally oriented sp3 hybrid orbitals with hydrogen 1s orbitals.*

**Q53.**

A clinician reviewing a structural formula of ethylene notes that the molecule is planar. Which bonding description accounts for this geometry?

**A)** Each carbon is sp3-hybridized with only sigma bonds
**B) Each carbon is sp2-hybridized with one unhybridized p orbital forming a pi bond ✓ Correct**
**C)** Each carbon is sp-hybridized with two pi bonds
**D)** Each carbon is unhybridized and uses only p orbitals

*Rationale: In ethylene, each carbon is sp2-hybridized, giving trigonal planar geometry and one unhybridized p orbital for the π bond.*

**Q54.**

A respiratory therapist compares acetylene and ethane in a safety training module. Which property is expected for the carbon–carbon bond in acetylene?

**A)** It is longer and weaker than the carbon–carbon bond in ethane
**B) It is shorter and stronger than the carbon–carbon bond in ethane ✓ Correct**
**C)** It has the same length but greater flexibility than the carbon–carbon bond in ethane
**D)** It is ionic rather than covalent

*Rationale: A carbon–carbon triple bond is both shorter and stronger than a carbon–carbon single bond.*

**Q55.**
A student intern draws a p orbital as two lobes separated by an empty region. What is the correct term for that zero-electron-density region?

**A)** Valence shell
**B)** Hybrid axis
**C) Node ✓ Correct**
**D)** Bonding domain

*Rationale: A node is the region of zero electron density separating the lobes of a p orbital.*

**Q56.**
A nurse educator asks why sodium chloride is described differently from methane in a chemistry refresher. Which distinction is correct?

**A)** Sodium chloride is a molecule because it contains covalent bonds
**B)** Methane is ionic because carbon reaches an octet by electron transfer
**C) Sodium chloride is held together by electrostatic attraction of ions, whereas methane is a covalent molecule ✓ Correct**
**D)** Methane contains no shared electrons, unlike sodium chloride

*Rationale: NaCl is an ionic compound formed by attraction between Na+ and Cl–, whereas methane is a molecule with shared-electron covalent bonds.*

**Q57.**
A toxicology researcher is sketching formaldehyde, CH2O, from its formula before entering it into a database. Which line-bond structure is correct?

**A)** H3C–O
**B)** H–C≡O–H
**C) H2C=O ✓ Correct**
**D)** H–O–CH

*Rationale: Formaldehyde contains a carbon–oxygen double bond and two hydrogens on carbon, giving H2C=O.*

**Q58.**
A chemistry tutor asks a pre-health student to identify the geometry around carbon in acetylene. What is the best answer?

**A)** Tetrahedral with bond angles near 109.5°
**B)** Trigonal planar with bond angles near 120°
**C) Linear with bond angles of 180° ✓ Correct**
**D)** Bent with bond angles near 104.5°

*Rationale: sp-Hybridized carbon in acetylene gives a linear arrangement with 180° bond angles.*

**Q59.**

During medication design training, a student is asked which rule states that electrons occupy equal-energy orbitals singly with parallel spins before pairing. Which rule applies?

**A)** Pauli exclusion principle
**B)** Aufbau principle
**C) Hund's rule ✓ Correct**
**D)** Octet rule

*Rationale: Hund's rule states that electrons fill degenerate orbitals singly with parallel spins before pairing.*

**Q60.**

A laboratory instructor asks why a covalent bond forms between two atoms. Which response is most accurate?

**A)** Bond formation always raises the energy of the system
**B) Bond formation lowers the energy and increases the stability of the system ✓ Correct**
**C)** Bond formation occurs only when electrons are completely transferred
**D)** Bond formation eliminates all lone-pair electrons

*Rationale: Atoms bond because the bonded state is lower in energy and therefore more stable than the separated atoms.*

**Q61.**

A biomedical researcher compares carbon and nitrogen when predicting simple bonding patterns in drug-like molecules. Why does neutral carbon typically form four covalent bonds while neutral nitrogen typically forms three?

**A) Carbon has four valence electrons and needs four more for an octet, whereas nitrogen has five and needs three more ✓ Correct**
**B)** Carbon has fewer electron shells than nitrogen
**C)** Nitrogen cannot form sigma bonds
**D)** Carbon always donates electrons while nitrogen always accepts electrons

*Rationale: Typical bonding follows the number of electrons needed to complete an octet: four for carbon and three for nitrogen.*

**Q62.**

A health informatics student is converting a structural image into text and sees a wedged bond and a dashed bond attached to carbon. What do these symbols indicate?

**A)** Double and triple bonds, respectively
**B)** Ionic and covalent bonds, respectively
**C) Bonds coming out of and going behind the plane of the page, respectively ✓ Correct**
**D)** Long and short bonds, respectively

*Rationale: A wedge shows a bond projecting toward the viewer, while a dashed bond shows one receding behind the plane.*

**Q63.**

A medicinal chemistry team is comparing sigma and pi bonds when discussing reactivity. Which statement correctly distinguishes them?

**A)** Sigma bonds arise from sideways overlap, and pi bonds arise from head-on overlap

**B) Sigma bonds are cylindrically symmetrical about the internuclear axis, whereas pi bonds have electron density above and below that axis ✓ Correct**

**C)** Pi bonds are stronger than sigma bonds because they always overlap more effectively

**D)** Sigma bonds can form only from s orbitals

*Rationale: σ bonds form by head-on overlap along the internuclear axis, while π bonds arise from sideways p-orbital overlap with density above and below the axis.*

**Q64.**

A hospital educator asks why carbon is uniquely central to organic chemistry. Which explanation is best?

**A)** Carbon is the heaviest common biological element

**B) Carbon can share four valence electrons and bond extensively to itself to form chains and rings ✓ Correct**

**C)** Carbon forms only ionic bonds in living systems

**D)** Carbon has the largest atomic radius among biologically important elements

*Rationale: Carbon's tetravalency and ability to bond strongly to other carbons enable immense structural diversity.*

**Q65.**

A student reviewing molecular orbital theory for a pharmacy entrance course asks what makes an antibonding molecular orbital unfavorable for bonding. Which answer is correct?

**A)** It places electron density primarily between nuclei

**B)** It has lower energy than the contributing atomic orbitals

**C) It contains a node between nuclei that prevents electron density from stabilizing the bond ✓ Correct**

**D)** It can hold only one electron

*Rationale: Antibonding orbitals have a node between nuclei, so electrons there do not stabilize the internuclear region.*

**Q66.**

A clinician sees the condensed formula (CH3)2CHCH2CH3 in a pharmacology handout. Which interpretation is correct?

**A) It represents a five-carbon chain with a methyl branch on the second carbon ✓ Correct**

**B)** It represents a straight six-carbon chain

**C)** It represents a four-carbon ring

**D)** It represents a molecule containing a carbon–carbon double bond

*Rationale: (CH3)2CHCH2CH3 corresponds to 2-methylbutane, a five-carbon structure with a methyl substituent on carbon 2.*

**Q67.**

A chemical safety officer compares methanol and methylamine. Which statement about oxygen and nitrogen hybridization in these molecules is most accurate?

**A) Both atoms are approximately sp3-hybridized and contain lone pairs occupying hybrid orbitals ✓ Correct**

**B)** Both atoms are sp-hybridized and linear

**C)** Oxygen is sp2-hybridized while nitrogen is always unhybridized

**D)** Nitrogen cannot have a lone pair in an organic molecule

*Rationale: In methanol and methylamine, oxygen and nitrogen are commonly described as approximately sp3-hybridized with lone pairs in sp3 orbitals.*

**Q68.**

A premedical student is asked why the carbon–carbon double bond in ethylene is not twice as strong as the single bond in ethane. What is the best explanation?

**A)** The second bond is ionic rather than covalent

**B) The pi bond from sideways overlap is weaker than the sigma bond from head-on overlap ✓ Correct**

**C)** Double bonds contain fewer electrons than single bonds

**D)** Bond strength is unrelated to orbital overlap

*Rationale: The π component of a double bond results from less effective sideways overlap and contributes less strength than a σ bond.*

**Q69.**

A molecular biology student is told that a p orbital has positive and negative lobes. What do these signs represent?

**A)** Actual positive and negative charges on the electron cloud

**B)** Different oxidation states of the atom

**C) Algebraic signs of the wave function that affect orbital combination ✓ Correct**

**D)** Regions that must contain paired and unpaired electrons

*Rationale: The plus and minus labels indicate the algebraic sign of the wave function, which determines constructive or destructive overlap.*

**Q70.**

A graduate nursing student asks why hydrogen is limited to one covalent bond in simple organic molecules. Which explanation is correct?

**A) Hydrogen has one valence electron and needs one more to reach the helium configuration ✓ Correct**

**B)** Hydrogen has no valence electrons available for bonding

**C)** Hydrogen must obey the octet rule and therefore makes eight bonds

**D)** Hydrogen forms one bond because it has one neutron

*Rationale: Hydrogen reaches a stable duet by sharing one additional electron, so it typically forms one covalent bond.*

**Q71.**
A radiopharmacy lab is selecting the correct isotope notation for an atom with 6 protons and 8 neutrons. Which isotope is being described?

**A)** Carbon-6
**B)** Carbon-8
**C)** Carbon-12
**D) Carbon-14 ✓ Correct**
*Rationale: Mass number equals protons plus neutrons, so 6 + 8 = 14, giving carbon-14.*

**Q72.**
A medical device company uses a hydrocarbon gas model in training. Which hybridization is expected for each carbon in ethane, CH3CH3?

**A)** sp on both carbons
**B)** sp2 on both carbons
**C) sp3 on both carbons ✓ Correct**
**D)** Unhybridized p orbitals only on both carbons
*Rationale: Each carbon in ethane forms four single bonds and is therefore sp3-hybridized.*

**Q73.**
A chemistry support specialist is checking a student's electron configuration for carbon. Which ground-state configuration is correct?

**A) 1s2 2s2 2p2 ✓ Correct**
**B)** 1s2 2s1 2p3
**C)** 1s2 2p4
**D)** 1s2 2s2 2p4
*Rationale: Carbon has six electrons, which fill as 1s2 2s2 2p2 in the ground state.*

**Q74.**
A pharmacist is reviewing phosphine, PH3, in a toxic exposure case. Based on valence considerations, how many covalent bonds does phosphorus form in phosphine?

**A)** One
**B)** Two
**C) Three ✓ Correct**
**D)** Five
*Rationale: Phosphorus has five valence electrons and typically forms three bonds in PH3 to complete an octet.*

**Q75.**
A student is interpreting a skeletal structure in a medicinal chemistry chart. According to standard skeletal notation, what is assumed at the end of an unlabeled line?

**A)** An oxygen atom
**B) A carbon atom with enough hydrogens to complete valence ✓ Correct**
**C)** A nitrogen atom with one lone pair
**D)** A charged atom that must be labeled separately
*Rationale: In skeletal structures, unlabeled line ends and intersections are assumed to be carbon atoms with implied hydrogens.*

**Q76.**
A hospital-based research team is comparing possible structures for a new volatile anesthetic intermediate. They need a molecule with a linear carbon center and two unhybridized p orbitals remaining on that carbon. Which hybridization fits this requirement?

**A)** sp3
**B)** sp2
**C) sp ✓ Correct**
**D)** dsp3

*Rationale: sp hybridization leaves two unhybridized p orbitals and gives linear geometry.*

**Q77.**
A medicinal chemist wants to predict the geometry around the carbonyl carbon in formaldehyde before modeling receptor binding. What geometry should be assigned to that carbon?

**A)** Tetrahedral, because carbon always forms four sigma bonds
**B) Trigonal planar, because the carbon is sp2-hybridized in a double bond ✓ Correct**
**C)** Linear, because the carbonyl bond contains a pi bond
**D)** Bent, because oxygen has lone pairs

*Rationale: The carbonyl carbon in formaldehyde is sp2-hybridized and therefore trigonal planar.*

**Q78.**
A nursing student compares the bond energies of H–H bond formation and bond breaking. Which statement is correct?

**A) The same amount of energy released on bond formation must be absorbed to break the bond ✓ Correct**
**B)** Bond formation absorbs energy, but bond breaking releases it
**C)** Bond energy changes only apply to ionic bonds
**D)** Breaking a bond requires no energy if the atoms are neutral

*Rationale: Bond formation releases energy, and the same magnitude of energy must be supplied to break that bond.*

**Q79.**
A biomedical engineering student is asked to identify the likely bond angle around each carbon in propene, CH3CH=CH2. Which set is most appropriate?

**A)** About 109.5° at all three carbons
**B)** About 120° at all three carbons
**C) About 109.5° at the CH3 carbon and about 120° at the two alkene carbons ✓ Correct**
**D)** About 180° at the CH3 carbon and about 120° at the alkene carbons

*Rationale: The methyl carbon is sp3 with tetrahedral angles, while the two double-bonded carbons are sp2 with trigonal planar angles.*

**Q80.**

A pharmacist is comparing a saturated hydrocarbon with an alkene during a drug synthesis review. Which structural feature is unique to the alkene carbon–carbon double bond?

**A)** Two sigma bonds between the carbons

**B) One sigma bond and one pi bond between the carbons ✓ Correct**

**C)** One pi bond only between the carbons

**D)** An ionic interaction between the carbons

*Rationale: A double bond consists of one σ bond and one π bond between the same two atoms.*

**Q81.**

A public health researcher is reviewing an infographic that labels an orbital as the region where an electron spends 90% to 95% of its time. Which interpretation is correct?

**A)** The orbital is a fixed circular path of the electron

**B) The orbital is a probability distribution describing likely electron location ✓ Correct**

**C)** The orbital is the exact position of the electron at all times

**D)** The orbital is a measure of atomic mass

*Rationale: An orbital represents a region of space where an electron is most likely to be found, not a fixed path.*

**Q82.**

A student in a pharmacology bridge course asks why carbon in methane does not achieve stability by gaining or losing four electrons. Which answer is best?

**A)** Carbon cannot undergo electron transfer under any conditions

**B) Gaining or losing four electrons would require too much energy, so carbon typically shares electrons instead ✓ Correct**

**C)** Carbon already has a full valence shell in methane

**D)** Hydrogen prevents carbon from forming an octet

*Rationale: For carbon, transfer of four electrons is energetically unfavorable, so it usually forms covalent bonds by sharing electrons.*

**Q83.**

A laboratory scientist is comparing the expected geometry of methylamine and methanol for a spectroscopy exercise. Which statement is most accurate?

**A) Both central heteroatoms are approximately tetrahedral in electron arrangement because they are sp3-hybridized ✓ Correct**

**B)** Both central heteroatoms are linear because lone pairs repel bonding pairs equally

**C)** Nitrogen is planar while oxygen is linear

**D)** Oxygen is trigonal planar while nitrogen is tetrahedral

*Rationale: Nitrogen in methylamine and oxygen in methanol are commonly described as sp3-hybridized with approximately tetrahedral electron arrangements.*

**Q84.**

A chemistry TA asks a student to compare the 2p orbitals within the same shell. Which statement is correct?

**A)** They differ in shape but not orientation

**B) They are identical in energy and oriented along mutually perpendicular directions ✓ Correct**

**C)** They are identical in orientation but differ in principal quantum number

**D)** Only one 2p orbital can exist in a shell

*Rationale: The three p orbitals in a shell have equal energy and are oriented along perpendicular axes.*

**Q85.**

A drug development team is evaluating whether a carbon atom in a candidate molecule is likely to be sp2-hybridized. Which observation would support that conclusion?

**A)** The carbon forms four single bonds with bond angles near 109.5°

**B)** The carbon is part of a triple bond with 180° bond angles

**C) The carbon is part of a double bond and shows approximately 120° bond angles ✓ Correct**

**D)** The carbon carries no valence electrons

*Rationale: sp2 hybridization is associated with double bonds and trigonal planar geometry near 120°.*

**Q86.**

A student is asked to identify the correct reason a pi bond cannot form from overlap of two s orbitals. What is the best answer?

**A)** s orbitals do not contain electrons

**B) Pi bonds require sideways overlap, which is characteristic of parallel p orbitals ✓ Correct**

**C)** s orbitals can overlap only in ionic compounds

**D)** Pi bonds always involve d orbitals

*Rationale: π bonds arise from sideways overlap of parallel p orbitals, not from spherical s orbitals.*

**Q87.**

A hospital educator wants a simple example of a molecule in which carbon is tetrahedral and represented with wedge-and-dash notation. Which molecule is the best choice from the chapter content?

**A) Methane ✓ Correct**

**B)** Ethylene

**C)** Acetylene

**D)** Hydrogen

*Rationale: Methane has an sp3-hybridized tetrahedral carbon and is commonly illustrated with wedge-and-dash geometry.*

**Q88.**

A medicinal chemistry student is comparing line-bond and Lewis structures. Which feature is shown explicitly in a Lewis structure but often omitted in a simple line-bond structure?

**A)** Atomic symbols for carbon

**B) Lone-pair electrons on heteroatoms ✓ Correct**

**C)** The presence of single bonds

**D)** The identity of heteroatoms

*Rationale: Lewis structures explicitly show valence electrons, including lone pairs, which are commonly omitted in line-bond drawings.*

**Q89.**

A research fellow is analyzing acetonitrile-like bonding and asks how many electron pairs are shared in a carbon–nitrogen triple bond. What is the correct answer?

**A)** One pair

**B)** Two pairs

**C) Three pairs ✓ Correct**

**D)** Four pairs

*Rationale: A triple bond consists of three shared electron pairs.*

**Q90.**

A pharmacy student is told that the 4s orbital fills before the 3d orbitals in many ground-state configurations. Which principle governs filling lower-energy orbitals first?

**A)** Hund's rule

**B)** Octet rule

**C) Aufbau principle ✓ Correct**

**D)** Pauli exclusion principle

*Rationale: The Aufbau principle states that electrons occupy the lowest-energy orbitals available first.*

**Q91.**

A clinical chemistry trainee is asked to predict whether C2H7 can represent a neutral stable organic molecule using normal valence rules. What is the best conclusion?

**A)** Yes, because carbon can expand its octet in second-row compounds

**B)** Yes, because hydrogen can form two bonds when attached to carbon

**C) No, because satisfying normal valences for two carbons and seven hydrogens would require an impossible bonding pattern ✓ Correct**

**D)** No, because molecules cannot contain an odd number of hydrogens

*Rationale: Two neutral tetravalent carbons cannot be combined with seven hydrogens without violating standard valence rules.*

**Q92.**

A biochemistry instructor asks why sp3 hybrid orbitals form stronger directional bonds than unhybridized s orbitals alone. Which explanation is best?

**A)** sp3 orbitals are symmetrical and therefore nonreactive

**B) sp3 orbitals are unsymmetrical, with a large lobe that overlaps more effectively with another orbital ✓ Correct**

**C)** sp3 orbitals contain more electrons than other orbitals

**D)** sp3 orbitals eliminate internuclear repulsion entirely

*Rationale: The large directional lobe of an sp3 hybrid orbital allows more effective overlap and stronger bonding.*

**Q93.**

A student reviewing molecular orbital theory for ethylene is asked which molecular orbital is occupied in the carbon–carbon pi system. Which answer is correct?

**A)** The higher-energy pi antibonding MO only

**B)** Both the bonding and antibonding pi MOs equally

**C) The lower-energy pi bonding MO, while the pi antibonding MO is unoccupied ✓ Correct**

**D)** Neither, because pi electrons remain in atomic orbitals

*Rationale: In ethylene, the π bonding MO is filled and the higher-energy π antibonding MO is vacant.*

**Q94.**

A healthcare simulation student must infer hydrogens from a skeletal drug fragment. A carbon at a three-way intersection with only single bonds and no heteroatom labels is assumed to have how many hydrogens?

**A)** Zero

**B) One ✓ Correct**

**C)** Two

**D)** Three

*Rationale: A three-way carbon intersection has three bonds shown, so one hydrogen is implied to complete carbon's valence of four.*

**Q95.**

A medicinal chemist evaluates whether a proposed structure containing a carbon–carbon triple bond inside a five-membered ring is likely to be stable. Which chapter-based reasoning best supports rejecting it?

**A)** Triple-bonded carbons prefer tetrahedral geometry

**B) Triple-bonded carbons require linear geometry, which is incompatible with a small ring such as cyclopentyne ✓ Correct**

**C)** Triple bonds can form only when hydrogen is attached to both carbons

**D)** Ring compounds cannot contain any multiple bonds

*Rationale: sp-Hybridized carbons in a triple bond require near-180° geometry, which small rings cannot accommodate well.*

**Q96.**

A student compares the central carbon in allene-like systems with the carbon in carbon dioxide. Which hybridization should be assigned to a carbon that forms two double bonds in a row?

**A)** sp3
**B)** sp2
**C) sp ✓ Correct**
**D)** dsp2

*Rationale: A carbon with two double bonds, as in allene or CO2, is best described as sp-hybridized.*

**Q97.**

A pharmacology trainee is asked to identify the outer-shell electron count for oxygen when drawing Lewis structures. How many valence electrons does neutral oxygen have?

**A)** Four
**B)** Five
**C) Six ✓ Correct**
**D)** Eight

*Rationale: Oxygen is a group 6A element and has six valence electrons.*

**Q98.**

A hospital laboratory mentor asks a student to choose the most appropriate representation for quickly sketching a large organic molecule while omitting most carbon and hydrogen labels. Which format is preferred?

**A)** Full electron-density surface
**B) Skeletal structure ✓ Correct**
**C)** Nuclear isotope notation
**D)** Orbital box diagram

*Rationale: Skeletal structures are the standard shorthand for large organic molecules because carbons and attached hydrogens are implied.*

**Q99.**

A medicinal chemistry case review compares methane, ethylene, and acetylene. Which trend in C–H bond strength is most consistent with the chapter data?

**A)** Methane > ethylene > acetylene
**B) Acetylene > ethylene > methane/ethane-type single-bond carbons ✓ Correct**
**C)** All C–H bond strengths are identical regardless of hybridization
**D)** Ethane > methane > acetylene

*Rationale: C–H bond strength increases from sp3 to sp2 to sp hybridization, with acetylene having the strongest C–H bond among these examples.*

**Q100.**

A graduate student preparing a teaching slide needs to justify why a carbon atom in a three-dimensional organic drawing can be represented as tetrahedral rather than planar. Which evidence is most directly relevant?

**A)** Carbon's nucleus contains protons and neutrons

**B) A carbon with four single bonds is described by four sp3 hybrid orbitals directed toward the corners of a tetrahedron ✓ Correct**

**C)** All atoms with four valence electrons are planar

**D)** Double bonds are always stronger than single bonds

*Rationale: The sp3 hybridization model directly explains the tetrahedral arrangement of a carbon bearing four single bonds.*