

Practice questions for Chem101

Try these out, *then* consult the answer key (at end of exam). If you got an answer wrong, watch the accompanying video in which Dr McIndoe quickly explains each solution.

1. KF, CaO and ScN are ionic substances. The ranking in lattice energies is given by:
 - A) Cannot be ranked without additional information
 - B) $KF > CaO > ScN$
 - C) $KF < CaO < ScN$
 - D) $KF < ScN < CaO$
 - E) $ScN < KF < CaO$
2. Of the interhalogen compounds ICl, ICl₃ and ICl₅, which statement concerning their molecular dipole moments is correct?
 - A) none have a net molecular dipole
 - B) all have a net molecular dipole
 - C) only ICl has a net molecular dipole
 - D) only ICl₃ has a net molecular dipole
 - E) only ICl and ICl₃ have net molecular dipoles
3. Draw a Lewis structure for the perchlorate ion, ClO₄⁻, that contains only single bonds. The formal charge on the Cl atom is what?
 - A) -1
 - B) 0
 - C) +1
 - D) +2
 - E) +3
4. Which of the following statements concerning dipole moment (μ) is INCORRECT?
 - A) μ is given in Debye (D)
 - B) the magnitude of μ is directly proportional to charge (Q)
 - C) μ is a vector quantity (it has a direction associated with it)
 - D) polar molecules have large values of μ
 - E) a polar diatomic molecule would have $\mu = 0$
5. If A > B means atom "A" is more electronegative than atom "B", the CORRECT ranking of electronegativities for elements F, C, Cl, Ge is:
 - A) $F > Cl > Ge > C$
 - B) $F > Cl > C > Ge$
 - C) $F > C > Cl > Ge$
 - D) $Cl > F > C > Ge$
 - E) $Cl > F > Ge > C$

6. The molecule $\text{H}_3\text{C}-\text{C}\equiv\text{C}-\text{H}$ has the following total number of hybridized orbitals:

- A) 2
- B) 4
- C) 6
- D) 8
- E) 10

7. Which of the following statements is CORRECT?

- i) Bonding electrons in metals are free to move from one bonding region to another
- ii) The electron-sea model explains the trends in melting points for the transition metals
- iii) The energy gap between bonding and antibonding molecular orbitals is largest for an insulator
- iv) There are no antibonding molecular orbitals for a semiconductor

- A) i
- B) i and ii
- C) ii and iii
- D) i and iii
- E) ii and iv

8. Which of the following molecules contain a central atom that violates the octet rule?

- A) SeF_2
- B) BH_3
- C) AsF_3
- D) CS_2
- E) SiCl_4

9. The molecular geometry of a molecule with the general formula AB_2 must be:

- A) linear or bent
- B) linear or trigonal planar
- C) T-shaped
- D) linear or T-shaped
- E) trigonal planar

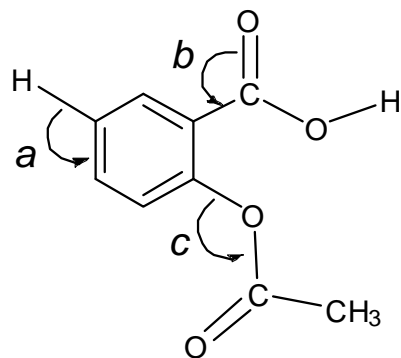
10. Assuming that the octet rule applies to all structures, which of the molecules { $\text{HC}\equiv\text{CH}$, HCN , CO } has a non-zero formal charge on carbon?

- A) $\text{HC}\equiv\text{CH}$
- B) HCN
- C) CO
- D) HCN and CO
- E) none

11. In the polar covalent bond C-Cl, the electrons in the bond are
- A) equally shared between the two atoms
 - B) completely transferred to the Cl atom to complete its octet
 - C) completely transferred to the C atom to complete its octet
 - D) unequally shared, being strongly attracted to the chlorine atom
 - E) the average positions of the electrons cannot be determined

12. A Lewis structure of aspirin is shown below. The approximate bond angle (in degrees, °) labeled "a", "b" and "c" in the drawing are, respectively:

- A) 120, 120, 120
- B) 120, 109, 180
- C) 180, 120, 120
- D) 120, 120, 109
- E) 109, 109, 120



Carry out a VSEPR analysis of the molecule **BrF₅** and answer questions 13 to 15 below.

13. The number of electron pairs (bonding and non-bonding) around the Br atom is
- A) 5 bonding, 0 non-bonding
 - B) 5 bonding, 1 non-bonding
 - C) 6 bonding, 0 non-bonding
 - D) 6 bonding, 1 non-bonding
 - E) 5 bonding, 2 non-bonding

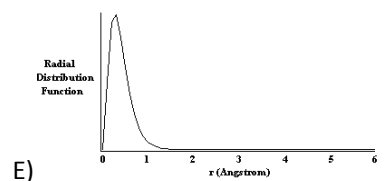
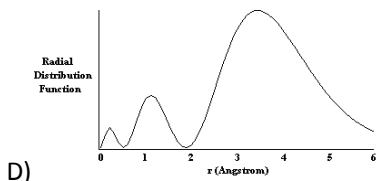
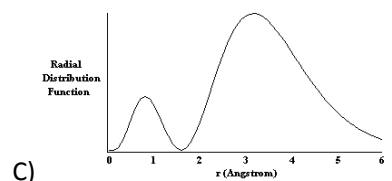
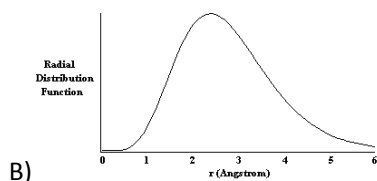
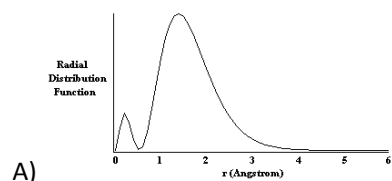
14. How many F-Br-F bond angles are approximately 90° in BrF₅?

- A) 0
- B) 1
- C) 8
- D) 6
- E) 4

15. The orbital hybridization around the Br atom in BrF₅ is:

- A) sp
- B) sp²d²
- C) sp²d³
- D) sp³d
- E) sp³d²

16. Which of the radial distribution functions below corresponds to an electron in a 3s orbital?



17. Why is it easier to remove a 2p electron from an oxygen atom than it is from a nitrogen atom?

- A) Oxygen has the highest effective nuclear charge
- B) Nitrogen has the highest effective nuclear charge
- C) It is easier to remove an electron from a doubly occupied orbital because of electron-electron repulsion
- D) Electrons with spin = $-\frac{1}{2}$ are easier to remove than those with spin = $+\frac{1}{2}$
- E) The p orbitals of oxygen are not degenerate

18. What is the electronic configuration of the Sn^{4+} ion?

- A) $[\text{Kr}] 5s^2 4d^8$
- B) $[\text{Kr}] 5s^2 4d^6 5p^2$
- C) $[\text{Kr}] 4d^{10}$
- D) $[\text{Kr}] 4d^8 5p^2$
- E) $[\text{Kr}] 5s^1 4d^8 5p^1$

19. Which element has the most negative electron affinity?

- A) Be
- B) B
- C) N
- D) O
- E) Ne

20. Which of these pairs of elements is in the WRONG order with respect to their relative size?

- A) $\text{Au} > \text{Cu}$
- B) $\text{Ca} > \text{Ga}$
- C) $\text{Bi} > \text{B}$
- D) $\text{Sb} > \text{Sn}$
- E) $\text{Pr} > \text{Er}$

21. When an electron is removed from an atom, is the resulting ion smaller or larger than the parent atom?

- A) Always smaller, as the electron is removed from the most spatially extended orbital and there are less electron-electron repulsions.
- B) Usually smaller, but it stays the same size if the electron is removed from a doubly-occupied orbital.
- C) There is effectively NO size change, because an electron is tiny compared the nucleus.
- D) Usually larger, but it stays the same size if the electron is removed from a doubly-occupied orbital.
- E) Always larger, because the number of attractive interactions between nucleus and electrons is reduced when an electron is removed.

22. Which of these statements about benzene is FALSE?

- A) the C-C bond lengths are all the same
- B) benzene exhibits delocalized bonding
- C) the C-C bonds have a bond order of 1.5
- D) three resonance structures are required to fully describe the bonding
- E) each carbon atom contributes one electron to the π bonding in benzene

23. Which of these statements about hybrid orbitals is FALSE?

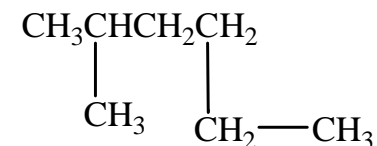
- A) mixing four atomic orbitals allows the formation of four hybrid atomic orbitals
- B) mixing an s orbital with two p orbitals generates three identical hybrid orbitals arranged at 120° with respect to each other.
- C) a square pyramidal molecule is hybridized sp^3d^2
- D) a linear arrangement of electron domains implies sp hybridization.
- E) BrF_3 is sp^2 hybridized

24. Methanol (CH_3OH) can form a hydrogen bond with:

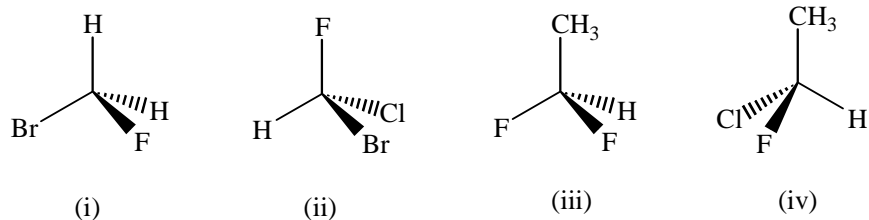
- A) ethane
- B) ethene
- C) bromine
- D) water
- E) polypropylene

25. The correct name for the compound below is:

- A) 1-ethyl-3-methylbutane
- B) 2-methylhexane
- C) 4-ethyl-2-methylbutane
- D) 1-ethylisopentane
- E) 1,1-dimethylpentane

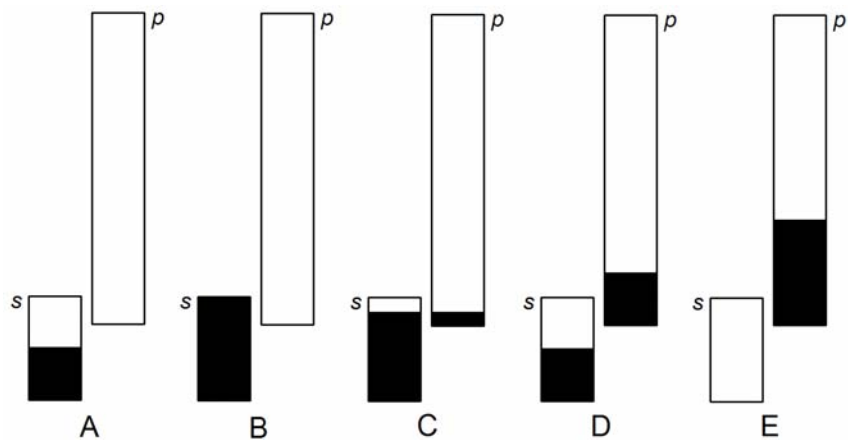


26. Which of the following molecules is/are chiral?

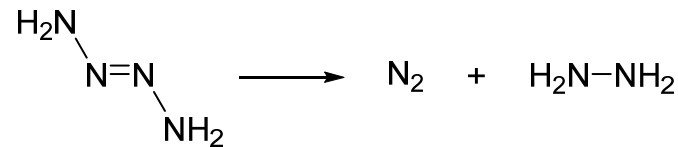


- A) all are chiral B) none are chiral C) (i), (ii) and (iv)
 D) (ii) and (iv) E) (ii), (iii) and (iv)

27. Which of these diagrams best describes the band structure of Mg?



28. Tetrazene decomposes above 0°C to form hydrazine and nitrogen gas, according to the reaction below. What is the enthalpy change in kJ mol^{-1} for this reaction?



- A) -418 B) -150 C) -364 D) -527 E) -552

29. The compounds Br_2 and ICl have the same number of electrons, yet Br_2 melts at -7°C and ICl melts at 27°C . Why?

- A) Br_2 is covalently bonded, whereas ICl has ionic bonding.
 B) I and Cl have different electronegativities, so the covalent bond is polar and the molecules are attracted by dipole-dipole forces.
 C) Br_2 is more polarizable than ICl .
 D) ICl has greater London dispersion forces than Br_2 .
 E) Br_2 experiences no intermolecular forces because the bond is non-polar.

30. Why is the electron affinity of Ge (-119 kJ mol^{-1}) a larger negative number than for As (-78 kJ mol^{-1})?

- A) The electronegativity of As is higher than that of Ge.
- B) The electronegativity of Ge is higher than that of As.
- C) The electron added to Ge goes into an empty orbital, whereas the electron added to As goes into an orbital that already has an electron in it.
- D) Ge is larger than As, and so can more easily accommodate an additional electron.
- E) Ge has a higher effective nuclear charge than As.

31. Which of these statements about nanomaterials is INCORRECT?

- A) Nanomaterials have dimensions in the 1-100 nm scale.
- B) Some properties of metals and semiconductors change when their dimensions are in the range 1-100 nm.
- C) The prefix "nano" means 10^{-9} .
- D) Nanoparticles made of the same material but of different sizes can have different colours.
- E) Nanoparticles have continuous molecular orbital bands, rather than discrete energy levels.

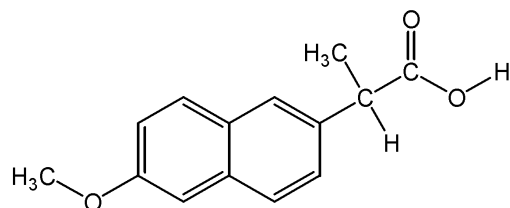
32. Which of the following molecules is a saturated hydrocarbon?

- A) 2-pentene
- B) ethyne
- C) butylhexanoate
- D) 2,2-dimethylbutane
- E) propanone

33. How many different isomers of $\text{C}_3\text{H}_8\text{O}$ can you draw?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

34. The structure below is of Naproxen, a non-steroidal anti-inflammatory drug. How many sp^3 hybridized CARBON atoms are present in this molecule?



- A) 1 B) 2 C) 3 D) 10 E) 11

35. What are the oxygen-containing functional groups in Naproxen?

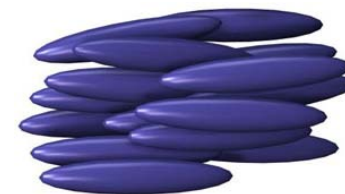
- A) An ether and a carboxylic acid
B) An ether and an ester
C) An ether and an aldehyde
D) An ester and a carboxylic acid
E) An ester and an aldehyde

36. Which of these statements about hybridization is CORRECT?

- A) Five atomic orbitals must be mixed to make an sp^3d hybridized atom.
B) Water is bent because the oxygen atom is sp^2 hybridized.
C) The bond angles are all 90° in all compounds with an sp^3d^2 hybridized central atom.
D) The carbon atoms in benzene, C_6H_6 , are all equivalent and sp hybridized.
E) The carbon atoms in hydrocarbons are always sp^3 hybridized.

37. The ellipsoidal rods in the picture below best represent molecules in a

- A. normal liquid
B. nematic liquid crystalline phase
C. smectic liquid crystalline phase
D. cholesteric liquid crystalline phase
E. crystalline solid



38. How many isomers of $C_4H_{10}O$ are ketones?

- A) 1 B) 2 C) 3 D) 4 E) 5

Answer key:

1. C 2. B 3. E 4. E 5. B 6. D 7. D 8. B 9. A 10. C 11. D 12. D 13. B
14. C 15. E 16. D 17. C 18. C 19. D 20. D 21. A 22. D 23. E 24. D 25. B 26. D
27. C 28. C 29. B 30. C 31. E 32. D 33. C 34. C 35. A 36. A 37. B 38. A