MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) The basis of the VSEPR model of molecular bonding is __________.
   A) regions of electron density in the valence shell of an atom will arrange themselves such as to maximize overlap
   B) electron domains in the valence shell of an atom will arrange themselves such as to minimize repulsions
   C) hybrid orbitals will form as necessary to, as closely as possible, achieve spherical symmetry
   D) regions of electron density on an atom will organize themselves such as to maximize $s$-character
   E) atomic orbitals of the bonding atoms must overlap for a bond to form

Answer: B

2) ClF$_3$ has "T-shaped" geometry. There are __________ non-bonding domains in this molecule.
   A) 2
   B) 1
   C) 3
   D) 4
   E) 0

Answer: A

3) The hybridization of the oxygen atom labeled y in the structure below is __________. The C-O-H bond angle is __________.

   \[ \text{H} - \text{C} = \text{C} - \text{O} - \text{H} \]
   \[ \text{H} - \text{C} - \text{H} \quad y \]

   A) sp, 180°
   B) sp$^2$, 109.5°
   C) sp, 90°
   D) sp$^3$d$^2$, 90°
   E) sp$^3$, 109.5°

Answer: E

4) There are __________ σ bonds and __________ π bonds in H$_3$C-CH$_2$·CH₃=CH-CH$_2$·C≡CH.
   A) 14, 2
   B) 16, 3
   C) 10, 3
   D) 12, 2
   E) 13, 2

Answer: B

5) Based on molecular orbital theory, there are __________ unpaired electrons in the OF$^+$ ion.
   A) $\frac{1}{2}$
   B) 0
   C) 1
   D) 2
   E) 3

Answer: D

6) Based on molecular orbital theory, the bond orders of the H–H bonds in H$_2$, H$_2^+$, and H$_2^-$ are __________, respectively
   A) 1, 0, and $\frac{1}{2}$
   B) 1, 1/2, and 1/2
   C) 1, 0, and 0
   D) 1, 2, and 0
   E) 1, 1/2, and 0

Answer: B

7) Based on molecular orbital theory, the bond order of the N–N bond in the N$_2$ molecule is __________.
   A) 0
   B) 1
   C) 2
   D) 3
   E) 5

Answer: D
8) The electron domain and molecular geometry of BrO\textsuperscript{2−} is ________.
   A) trigonal pyramidal, seesaw  
   B) tetrahedral, trigonal planar  
   C) tetrahedral, bent  
   D) trigonal pyramidal, linear  
   E) trigonal planar, trigonal planar  
   Answer: C

9) The molecular geometry of the right-most carbon in the molecule below is ________.

   ![Molecule Diagram]
   A) trigonal planar  
   B) trigonal bipyramidal  
   C) tetrahedral  
   D) T-shaped  
   E) octahedral  
   Answer: A

10) The bond angles marked a, b, and c in the molecule below are about ________, ________, and ________ respectively.

   ![Molecule Diagram]
   A) 109.5°, 120°, 109.5°  
   B) 109.5°, 90°, 120°  
   C) 120°, 120°, 109.5°  
   D) 120°, 120°, 90°  
   E) 90°, 90°, 90°  
   Answer: A

11) The molecular geometry of the SF\textsubscript{6} molecule is ________, and this molecule is ________.

   A) octahedral, nonpolar  
   B) trigonal planar, nonpolar  
   C) trigonal planar, polar  
   D) trigonal bipyramidal, polar  
   E) trigonal pyramidal, polar  
   Answer: A

12) Based on molecular orbital theory, the bond order of the N–N bond in the \textit{N}2\textsuperscript{2+} ion is ________.

   A) 2  
   B) 3  
   C) 0  
   D) 1/2  
   E) 1  
   Answer: A
13) Of the following, ________ appear(s) to gain mass in a magnetic field.

\[
\begin{array}{ccc}
B_2 & N_2 & O_2 \\
\end{array}
\]

A) N₂ and O₂  B) B₂ and N₂  C) B₂ and O₂  D) N₂ only  E) O₂ only

Answer: C

14) In which of the following molecules is hydrogen bonding likely to be the most significant component of the total intermolecular forces?

A) CH₄  B) C₆H₁₃NH₂  C) C₅H₁₁OH  D) CO₂  E) CH₃OH

Answer: E

15) What types of intermolecular forces exist between HI and H₂S?

A) dispersion forces and dipole-dipole  
B) dipole-dipole and ion-dipole  
C) dispersion forces, dipole-dipole, and ion-dipole  
D) dispersion forces, dipole-dipole, and ion-dipole  
E) dispersion forces, hydrogen bonding, dipole-dipole, and ion-dipole

Answer: A

16) Which statements about viscosity are true?

(i) Viscosity increases as temperature decreases.
(ii) Viscosity increases as molecular weight increases.
(iii) Viscosity increases as intermolecular forces increase.

A) (i) only  B) (ii) and (iii)  C) (i) and (iii)  D) none  E) all

Answer: E

17) Based on the following information, which compound has the strongest intermolecular forces?

<table>
<thead>
<tr>
<th>Substance</th>
<th>ΔHᵥap (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon (Ar)</td>
<td>6.3</td>
</tr>
<tr>
<td>Benzene (C₆H₆)</td>
<td>31.0</td>
</tr>
<tr>
<td>Ethanol (C₂H₅OH)</td>
<td>39.3</td>
</tr>
<tr>
<td>Water (H₂O)</td>
<td>40.8</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>9.2</td>
</tr>
</tbody>
</table>

A) Benzene  B) Water  C) Methane  D) Ethanol  E) Argon

Answer: B

18) The slope of a plot of the natural log of the vapor pressure of a substance versus 1/T is ________.

A) -ΔHᵥap  B) -ΔHᵥap/R  C) -1/ΔHᵥap  D) 1/ΔHᵥap  E) ΔHᵥap

Answer: B

19) The strongest interparticle attractions exist between particles of a ________ and the weakest interparticle attractions exist between particles of a ________.

A) solid, liquid  B) liquid, gas  C) solid, gas  D) gas, solid  E) liquid, solid

Answer: C

20) Which one of the following exhibits dipole-dipole attraction between molecules?

A) C₁₀H₂₂  B) Br₂  C) PH₃  D) CCl₄  E) CO₂

Answer: C
21) Of the following, ________ has the highest boiling point.
   A) O₂  B) N₂  C) Br₂  D) H₂  E) Cl₂  
   Answer: C

22) Which of the following is most likely to exhibit liquid-crystalline behavior?
   A) CH₃CH₂CH₂CH₂CH₂⁻ Na⁺  
   B)  
   C) CH₃CH₂CH₂CH₂CH₂CH₂CH₃  
   D)  
   E) CH₃CH₂-C(CH₃)₂-CH₂CH₃  
   Answer: D

23) The reaction of 50 mL of Cl₂ gas with 50 mL of C₂H₄ gas via the equation:
   Cl₂ (g) + C₂H₄ (g) →C₂H₄Cl₂ (g)
   will produce a total of ______ mL of products if pressure and temperature are kept constant.
   A) 100  B) 125  C) 50  D) 150  E) 25  
   Answer: C

24) The volume of a sample of gas (2.49 g) was 752 mL at 1.98 atm and 62 °C. The gas is ________.
   A) NH₃  B) Ne  C) SO₃  D) NO₂  E) SO₂  
   Answer: D

25) The density of NO₂ in a 4.50 L tank at 760.0 torr and 25.0 °C is ________ g/L.
   A) 1.68  B) 1.88  C) 3.27  D) 1.64  E) 9.30  
   Answer: B

26) Of the following gases, ________ will have the greatest rate of effusion at a given temperature.
   A) NH₃  B) Ar  C) CH₄  D) HBr  E) HCl  
   Answer: C

27) The pressure exerted by a column of liquid is equal to the product of the height of the column times the gravitational constant times the density of the liquid, P = ghρ. How high a column of water (d = 1.0 g/mL) would be supported by a pressure that supports a 713 mm column of mercury (d = 13.6 g/mL)?
   A) 1.2 ×10⁴ mm  
   B) 9.7 ×10³ mm  
   C) 713 mm  
   D) 52 mm  
   E) 14 mm  
   Answer: B
28) The volume of an ideal gas is zero at __________.
   A) -45 °F  B) -273 °C  C) -363 K  D) 0 °C  E) -273 K
   Answer: B

29) Standard temperature and pressure (STP), in the context of gases, refers to __________.
   A) 273.15 K and 1 atm  B) 298.15 K and 1 atm  C) 298.15 K and 1 torr  
   D) 273.15 K and 1 pascal  E) 273.15 K and 1 torr
   Answer: A

30) Which one of the following gases would deviate the least from ideal gas behavior?
   A) CH₃Cl  B) Ne  C) Kr  D) CO₂  E) F₂
   Answer: B

31) Which noble gas is expected to show the largest deviations from the ideal gas behavior?
   A) argon  B) neon  C) xenon  D) krypton  E) helium
   Answer: C

32) The process of doping can produce a __________ which can greatly __________ intrinsic conductivity.
   A) allotrope, diminish  B) non- metal, increase  C) non- metal, decrease  
   D) p- type semiconductor, decrease  E) n- type semiconductor, increase
   Answer: E

33) The formation of a condensation polymer generally involves __________.
   A) the mixing of sulfur with an addition polymer  
   B) the elimination of a small molecule  C) the addition of a plasticizer  
   D) the formation of significant crosslinking  E) the vaporization of a plasticizer
   Answer: B

34) Which of the following is not classified as a nanomaterial?
   A) buckminsterfullerene  B) isoprene  C) carbon nanotubes  D) graphene  
   E) All of the above are classified as nanomaterials
   Answer: B

35) Which of the following is not a type of solid?
   A) supercritical  B) molecular  C) metallic  D) ionic  E) covalent-network
   Answer: A
36) The scattering of light waves upon passing through a narrow slit is called __________.
   A) diffusion  B) adhesion  C) incidence  D) grating  E) diffraction
   Answer: E

37) If the electronic structure of a solid substance consists of a valence band that is completely filled with electrons and there is a large energy gap to the next set of orbitals, then this substance will be a(n) __________.
   A) conductor  B) nonmetal  C) semiconductor  D) insulator  E) alloy
   Answer: D

38) What fraction of the volume of each corner atom is actually within the volume of a face-centered cubic unit cell?
   A) 1  B) 1/2  C) 1/4  D) 1/8  E) 1/16
   Answer: D

39) NaCl crystallizes in a face-centered cubic cell. What is the total number of ions (Na$^+$ ions and Cl$^-$ ions) that lie within a unit cell of NaCl?
   A) 4  B) 5  C) 8  D) 2  E) 6
   Answer: C

40) Inorganic compounds that are semiconductors have an average of ________ valence electrons.
   A) 5  B) 4  C) 2  D) 3  E) 1
   Answer: B