MULTIPLE CHOICE. (3 points)

1) A sample of a gas (5.0 mol) at 1.0 atm is expanded at constant temperature from 10 L to 15 L. The final pressure is __________ atm.
   A) 3.3  B) 1.5  C) 15  D) 7.5  E) 0.67

2) The shape of a liquid's meniscus is determined by __________.
   A) the type of material the container is made of
   B) the viscosity of the liquid
   C) the relative magnitudes of cohesive forces in the liquid and adhesive forces between the liquid and its container
   D) the amount of hydrogen bonding in the liquid
   E) the volume of the liquid

3) The phase diagram of a substance is given above. This substance is a __________ at 25°C and 1.0 atm.

   A) solid  B) gas  C) liquid  D) crystal  E) supercritical fluid

4) According to MO theory, overlap of two s atomic orbitals produces __________.
   A) two bonding molecular orbitals
   B) two bonding molecular orbitals and two antibonding molecular orbitals
   C) two bonding molecular orbitals and one antibonding molecular orbital
   D) one bonding molecular orbital and one antibonding molecular orbital
   E) one bonding molecular orbital and one hybrid orbital

5) Crystalline solids differ from amorphous solids in that crystalline solids have __________.
   A) atoms, molecules, or ions that are close together
   B) much larger atoms, molecules, or ions
   C) no orderly structure
   D) appreciable intermolecular attractive forces
   E) a long-range repeating pattern of atoms, molecules, or ions

6) Which one of the following exhibits dipole-dipole attraction between molecules?
   A) XeF₄  B) AsH₃  C) BCl₃  D) Cl₂  E) CO₂
7) Hydrogen bonding is a special case of _________.
   A) dipole-dipole attractions   B) ion-dipole attraction
   C) London-dispersion forces   D) none of the above
   E) ion-ion interactions

8) A typical double bond _________.
   A) is stronger and shorter than a single bond
   B) consists of two shared electron pairs
   C) consists of one sigma bond and one pi bond
   D) imparts rigidity to a molecule
   E) All of the above answers are correct.

9) Of the molecules below, only ________ is nonpolar.
   A) NH₃   B) TeCl₂   C) H₂O   D) CO₂   E) HCl

10) On a phase diagram, the critical temperature is _________.
    A) the temperature below which a gas cannot be liquefied
    B) the temperature required to melt a solid
    C) the temperature above which a gas cannot be liquefied
    D) the temperature required to cause sublimation of a solid
    E) the temperature at which all three states are in equilibrium

11) Which of the following statements about gases is false?
    A) Bases are highly compressible.
    B) All gases are colorless and odorless at room temperature.
    C) Gases expand spontaneously to fill the container they are placed in.
    D) Distances between molecules of gas are very large compared to bond distances within molecules.
    E) Non-reacting gas mixtures are homogeneous.

12) In a gas mixture of He, Ne, and Ar with a total pressure of 8.40 atm, the mole fraction of Ar is ________
    if the partial pressures of He and Ne are 1.50 and 2.00 atm, respectively.
    A) 0.583   B) 0.238   C) 0.417   D) 0.179   E) 0.357

13) According to VSEPR theory, if there are four electron domains in the valence shell of an atom, they will be
    arranged in a(n) ________ geometry.
    A) linear   B) trigonal planar   C) trigonal bipyramidal
    D) tetrahedral   E) octahedral

14) Which one of the following gases would have the highest average molecular speed at 25°C?
    A) CO₂   B) SF₆   C) N₂   D) O₂   E) CH₄

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

16) There are ________ sigma and ________ pi bonds in the H₂C=C=CH₂ molecule.
    A) 4, 2   B) 6, 4   C) 2, 6   D) 6, 2   E) 2, 2
17) A gas is __________ and assumes __________ of its container whereas a liquid is __________ and assumes __________ of its container.
A) compressible, the shape, not compressible, the volume and shape
B) condensed, the volume and shape, condensed, the volume and shape
C) condensed, the shape, compressible, the volume and shape
D) compressible, the volume and shape, not compressible, the shape of a portion
E) compressible, the volume and shape, compressible, the volume

18) The direct conversion of a solid to a gas is called __________.
A) vaporization  B) fusion  C) sublimation  D) boiling  E) condensation

19) The molecular geometry of __________ is square planar.
A) XeF\(_4\)  B) CCl\(_4\)  C) PH\(_3\)  D) ICl\(_3\)  E) XeF\(_2\)

20) There are __________ unhybridized p atomic orbitals in an sp-hybridized carbon atom.
A) 0  B) 1  C) 2  D) 3  E) 4

21) Of the following, only __________ has sp\(^2\) hybridization of the central atom.
A) ICl\(_3\)  B) I\(_3^-\)  C) PF\(_5\)  D) CO\(_3^{2-}\)  E) PH\(_3\)

22) Of the following, __________ is a correct statement of Boyle's law.
A) n/P = constant  B) P/V = constant  C) V/T = constant  D) PV = constant  E) V/P = constant

23) If 3.21 mol of a gas occupies 56.2 L at 44°C and 793 torr, 5.29 mol of this gas occupies __________ L under these conditions.
A) 30.9  B) 14.7  C) 478  D) 61.7  E) 92.6

24) The heating curve shown was generated by measuring the heat flow and temperature for a solid as it was heated. The slope of the __________ segment corresponds to the heat capacity of the liquid of the substance.

![Heating curve diagram]

A) AB  B) BC  C) CD  D) DE  E) EF

25) Which statement about ideal behavior of gases is false?
A) All particles in the ideal gas behave independently of each other.
B) The Kelvin temperature of a gas indicates the average kinetic energy of the substance.
C) Large volumes and high temperatures typically cause deviations from the ideal gas behavior.
D) Volume of 2.00 moles of oxygen gas, O\(_2\), is assumed to be the same as that of 2.00 moles of carbon dioxide gas, CO\(_2\), as long as the temperature and pressure conditions are the same.
E) Gas ideality assumes that there are no interactions between gas particles.
What type(s) of intermolecular forces is (are) common to:

a) CH₂OH and CH₃CN

- dipole-dipole and London-dispersion forces
  Both compounds are organic compounds with low polarity.

b) NH₃ and HF

- Hydrogen bonding
  Both compounds are very polar and have hydrogen bonded to a highly electronegative compound.

Using bond enthalpies, calculate the enthalpy change for the following reaction:

\[
\text{H-Si-Cl} + \text{H-C-H} \rightarrow \text{H-Si-C-H} + \text{H-Cl}
\]

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond Enthalpy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si-H</td>
<td>323</td>
</tr>
<tr>
<td>Si-Cl</td>
<td>464</td>
</tr>
<tr>
<td>C-H</td>
<td>413</td>
</tr>
<tr>
<td>Si-C</td>
<td>301</td>
</tr>
<tr>
<td>H-Cl</td>
<td>431</td>
</tr>
</tbody>
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\[
\Delta H_{\text{rxn}} = \sum (\text{bonds broken}) - \sum (\text{bonds formed})
\]

\[
= [1\text{mol}(\text{Si-Cl}) + 1\text{mol}(\text{C-H})] - [1\text{mol}(\text{Si-C}) + 1\text{mol}(\text{H-Cl})]
\]

\[
= [1\text{mol}(464\text{kJ/mol}) + 1\text{mol}(413\text{kJ/mol})] - [1\text{mol}(301\text{kJ/mol}) + 1\text{mol}(431\text{kJ/mol})]
\]

\[
= 145\text{kJ}
\]
Ammonium sulfate, an important fertilizer, can be prepared by the reaction of ammonia with sulfuric acid:

\[ 2 \text{NH}_3(g) + \text{H}_2\text{SO}_4(aq) \rightarrow (\text{NH}_4)_2\text{SO}_4(aq) \]

Calculate the volume of NH\(_3\)(g) needed at 42°C and 15.6 atm of react with 87kg of H\(_2\)SO\(_4\).

For this problem, you will first need to determine the moles of ammonia, then use the gas law to determine the volume of ammonia.

\[
\text{moles H}_2\text{SO}_4 = \frac{87\text{kg} \times (1000\text{g/kg})}{98.02\text{g/mol}} = 887.57\text{ moles}
\]

\[
\frac{2\text{NH}_3}{1\text{H}_2\text{SO}_4} = \frac{x}{887.57\text{ mol}}
\]

\[
x = 1775.15\text{ mol NH}_3
\]

\[
T = 42.0°C + 273 = 315K
\]

\[
P = 15.6\text{atm}
\]

\[
n_{\text{NH}_3} = 1775.15\text{ mol}
\]

\[
R = 0.08206\text{L(atm)/mol(K)}
\]

\[
PV = nRT
\]

\[
15.6\text{atm}V = 1775.15\text{ mol}(0.08206)(315K)
\]

\[
V = 2,941.4\text{L}
\]

\[
= 2.9 \times 10^3\text{L}
\]