Atomic weight: H, 1.01; C, 12.01; N, 14.01; O, 16.00.
Gas constant: R = 8.314 J/mol-K = 0.08206L-atm/mol-K

1. 单一选择题 每题3分，共计60分

B (1) In the molecule below, which atom has the largest partial negative charge?

\[ \text{Br} \quad \text{F} \quad \text{C} \quad \text{I} \]

(A) Cl  (B) F  (C) Br  (D) I  (E) C.

C (2) The formal charge on nitrogen in NO\(_3^–\) is ________

(A) -1  (B) 0  (C) +1  (D) +2  (E) -2

D (3) Using the table of average bond energies below, the ΔH for the reaction

\[ \text{H}–\text{C}≡\text{C}–\text{H}_\text{(g)} + \text{H}–\text{I}_\text{(g)} \longrightarrow \text{H}_2\text{C}=\text{CHI}_\text{(g)} \]

is ______ kJ.

<table>
<thead>
<tr>
<th>Bond</th>
<th>C≡C</th>
<th>C=C</th>
<th>H–I</th>
<th>C–I</th>
<th>C–H</th>
</tr>
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<tbody>
<tr>
<td>ΔH (kJ/mol)</td>
<td>839</td>
<td>614</td>
<td>299</td>
<td>240</td>
<td>413</td>
</tr>
</tbody>
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(A) +506  (B) -931  (C) -506  (D) -129  (E) +129

B (4) Which of the following has the bonds correctly arranged in order of increasing polarity?

(A) Be–F, Mg–F, N–F, O–F  (B) O–F, N–F, Be–F, Mg–F

(C) O–F, Be–F, Mg–F, N–F  (D) N–F, Be–F, Mg–F, O–F

(E) O–F, Mg–F, Be–F, N–F

B (5) The molecular geometry of SF\(_2\) is ________.

(A) linear  (B) bent  (C) trigonal planar  (D) tetrahedral

(E) octahedral

E (6) The hybridization of the central atom in the XeF\(_4\) molecule is ________

(A) sp  (B) sp\(^2\)  (C) sp\(^3\)  (D) sp\(^3\)d  (E) sp\(^3\)d\(^2\)

D (7) Which of the following species will have bond angles of 120°?

(A) PH\(_3\)  (B) ClF\(_3\)  (C) NCl\(_3\)  (D) BCl\(_3\)  (E) none of above

B (8) Base on the molecular orbital theory, the bond order of the N–N bond in the N\(_2^+\) ion is _____.

(A) 3  (B) 2.5  (C) 2  (D) 1.5  (E) 1

D (9) A flask contains a mixture of He and Ne at a total pressure of 2.6 atm. There are 2.0 mol of He and 5.0 mol of Ne in the flask. The partial pressure of He is _____ atm.

(A) 9.1  (B) 6.5  (C) 1.04  (D) 0.74  (E) 1.86

D (10) Which of the following gases would deviate the least from ideal gas behavior?

(A) CH\(_3\)Cl  (B) Kr  (C) CO  (D) Ne  (E) F\(_2\)

C (11) A root-mean-square speed of CO at 113°C is _______ m/s.

(A) 317  (B) 58.3  (C) 586  (D) 993  (E) 31.5

D (12) What intermolecular force is responsible for the fact that ice is less dense than liquid water?

(A) London dispersion forces  (B) dipole-dipole forces  (C) ion-dipole forces

(D) hydrogen bonding  (E) ionic bonding
(13) Of the following, ______ is the most volatile.
(A) CH₄  (B) CCl₄  (C) CBr₄  (D) CF₄  (E) CHBr₃

(14) According to the phase diagram shown below, the normal boiling point of this substance is _____ °C.

(15) The slope of a plot of the natural log of the vapor pressure (lnP) of a substance versus the reciprocal of the temperature (1/T) is _______.
(A) ΔHᵥap  (B) -ΔHᵥap  (C) 1/ΔHᵥap  (D) -1/ΔHᵥap  (E) -ΔHᵥap/R

(16) The solubility of Ar in water at 25°C is 1.6 × 10⁻³ M when the pressure of the Ar above the solution is 1.0 atm. The solubility of Ar at a pressure of 2.5 atm is _____ M.
(A) 4.0 × 10⁻³  (B) 6.4 × 10⁻⁴  (C) 1.6 × 10⁻³  (D) 7.5 × 10⁻²  (E) 1.6 × 10⁻³

(17) A solution is prepared by dissolving 15.0 g of NH₃ in 250 g of water. The density of the resulting solution is 0.974 g/mL. The molarity of NH₃ in the solution is ________ M.
(A) 0.00353  (B) 0.882  (C) 60.0  (D) 3.53  (E) 3.24

(18) What is the freezing point of a solution prepared by dissolving 11.3 g of Ca(NO₃)₂ (formula weight = 164 g/mol) in 115 g of water? (Given Kᵥ = 1.86°C/m for water)
(A) –3.34°C  (B) –1.11°C  (C) 3.34°C  (D) 1.11°C  (E) 0°C

(19) Which of the following choices has the compounds correctly arranged in order of increasing solubility in water?
(A) CCl₄ < CHCl₃ < NaNO₃  (B) CH₃OH < CH₄ < LiF  (C) CH₄ < NaNO₃ < CHCl₃  (D) LiF < NaNO₃ < CHCl₃  (E) CH₃OH < CH₄ < CHCl₃

(20) Which of the following is not a colloid?
(A) frog  (B) milk  (C) air  (D) smoke  (E) whipped cream

2. Write Lewis structures that obey octet rule for each of the following, and assign the oxidation numbers on all atoms (A) POCl₃ (P is the central atom); (B) HClO₃ (H is bonded to O); (C) CO₃²⁻.  (9 points)

(A)  
(B)  
(C)  

8.49
3. The Lewis structure for allene is

\[
\text{H} \quad \begin{array}{c}
\overset{\approx}{\text{C}} \quad \overset{\approx}{\text{C}} \\
\text{H} & \text{H}
\end{array}
\text{H}
\]

Answer the following questions on the base of the structure of allene:
(A) Is this molecule planar? (B) Does it have a nonzero dipole moment? (C) Would the bonding in allene be described as delocalized?  
(5 points)

(a) The molecule is not planar. The CH₂ planes at each end are twisted 90° from one another.

(b) Allene has no dipole moment.

(c) The bonding in allene would not be described as delocalized. The π electron clouds of the two adjacent C=C are mutually perpendicular. The mechanism for delocalization of π electrons is mutual overlap of parallel p atomic orbitals on adjacent atoms. If adjacent π electron clouds are mutually perpendicular, there is no overlap and no delocalization of π electrons.

4. The molecules SiF₄, SF₄ and XeF₄ all have molecular formulas of the type AF₄, but the molecules have different molecular geometries. Predict the shape of each molecule, and explain why the shapes differ.  
(6 points)

5. The metabolic oxidation of glucose, C₆H₁₂O₆, in our bodies produces CO₂, which is expelled from our lungs as a gas:

\[
\text{C}_6\text{H}_12\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(l)
\]

Calculate the volume of dry CO₂ produced at body temperature (37°C) and 0.970 atm when 24.5 g of glucose is consumed in this reaction.  
(5 points)

\[
24.5 \text{ g} \times \frac{1 \text{ mol glucose}}{180.1 \text{ g}} \times \frac{6 \text{ mol CO}_2}{1 \text{ mol glucose}} = 0.8162 \text{ mol CO}_2
\]

\[
V = \frac{nRT}{P} = 0.8162 \text{ mol} \times \frac{0.08206 \text{ L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \times \frac{310 \text{ K}}{0.970 \text{ atm}} = 21.4 \text{ L CO}_2
\]
6. A gaseous mixture of O\textsubscript{2} and Kr has a density of 1.104 g/L at 435 torr and 300 K. What is the mole percent O\textsubscript{2} in the mixture? (5 points)

\[ MM_{\text{avg}} = \frac{dRT}{P} = \frac{1.104 \text{ g}}{1 \text{ L}} \times \frac{0.08206 \text{ L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \times \frac{300 \text{ K}}{435 \text{ torr}} \times \frac{760 \text{ torr}}{1 \text{ atm}} = 47.48 = 47.5 \text{ g/mol} \]

\[ \chi = \text{mole fraction O}_2; \ 1 - \chi = \text{mole fraction Kr} \]

\[ 47.48 \text{ g} = \chi(32.00) + (1 - \chi)(83.80) \]

\[ 36.3 = 51.8 \chi; \ \chi = 0.701; \ 70.1\% \text{ O}_2 \]

7. Iridium crystallizes in a face-centered cubic unit cell that has an edge length of 3.833 Å. The atom in the center of the face is contact with the corner atoms, as shown in the drawing.

(A) Calculate the atomic radius of an iridium atom. (B) Calculate the density of iridium metal. (5 points)

\[ 4 \ r = \sqrt{2} \ a; \ r = \frac{\sqrt{2} \ a}{4} = \frac{\sqrt{2} \times 3.833 \text{ Å}}{4} = 1.3552 = 1.355 \text{ Å} \]

(b) The density of iridium is the mass of the unit cell contents divided by the unit cell volume. There are 4 Ir atoms in a face-centered cubic unit cell.

\[ \frac{4 \text{ Ir atoms}}{(3.833 \times 10^{-8} \text{ cm})^3} \times \frac{192.22 \text{ g Ir}}{6.022 \times 10^{23} \text{ Ir atoms}} = 22.67 \text{ g/cm}^3 \]

8. Lysozyme is an enzyme that breaks bacterial cell walls. A solution containing 0.150 g of this enzyme in 210 mL of solution has an osmotic pressure of 0.953 torr at 25°C. What is the molar mass of lysozyme? (5 points)

\[ \pi = MRT; \ \ M = \frac{\pi}{RT}; \ \ T = 25^\circ \text{C} + 273 = 298 \text{ K} \]

\[ M = 0.953 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} \times \frac{\text{K} \cdot \text{mol}}{0.08206 \text{ L} \cdot \text{atm}} \times \frac{1}{298 \text{ K}} = 5.128 \times 10^{-5} = 5.13 \times 10^{-5} \text{ M} \]

\[ \text{mol} = M \times L = 5.128 \times 10^{-5} \times 0.210 \text{ L} = 1.077 \times 10^{-5} = 1.08 \times 10^{-5} \text{ mol lysozyme} \]

\[ \text{MM} = \frac{\frac{0.150 \text{ g}}{1.077 \times 10^{-5} \text{ mol}}}{\text{mol}} = 1.39 \times 10^4 \text{ g/mol lysozyme} \]