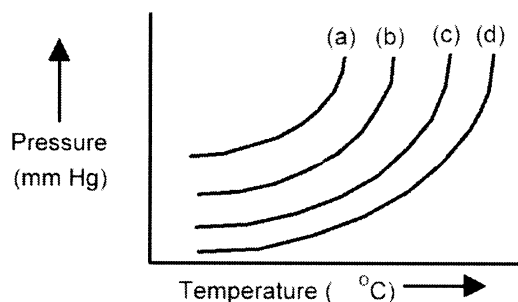


I. 單選題：(每題二分)

- Which of the following underlined items is *not* an intensive property?
 - A chemical reaction requires 3.00 g of oxygen.
 - Solid copper hydroxide is blue colored.
 - The density of helium at 25°C is 1.64×10^{-4} g/cm³.
 - The melting point of aluminum metal is 933 K.
- Which of the following statements is *not* a postulate of Dalton's atomic theory?
 - Each element is characterized by the mass of its atoms.
 - Atoms are composed of protons, neutrons, and electrons.
 - Chemical reactions only rearrange atomic combinations.
 - Elements are composed of atoms.
- Which are isotopes? An atom that has an atomic number of 34 and a mass number of 76 is an isotope of an atom that has
 - an atomic number of 32 and a mass number of 76.
 - an atomic number of 34 and a mass number of 80.
 - 42 neutrons and 34 protons.
 - 42 protons and 34 neutrons.
- 10 g of nitrogen is reacted with 5.0 g of hydrogen to produce ammonia according to the chemical equation shown below. Which one of the following statements is *false*?
$$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$$
 - 2.8 grams of hydrogen are left over.
 - Hyogen is the excess reactant.
 - Nitrogen is the limiting reactant.
 - The theoretical yield of ammonia is 15 g.
- For a multielectron atom, a 3s orbital lies lower in energy than a 3p orbital because
 - a 3p orbital has more nodal surfaces than a 3s orbital.
 - other electrons more effectively shield electrons in the 3s orbital from the nucleus.
 - other electrons more effectively shield electrons in the 3p orbital from the nucleus.
 - there are more p orbitals than s orbitals in a given shell.
- According to the Balmer-Rydberg equation, electromagnetic radiation with the shortest wavelength will be **emitted** when an electron undergoes which of the following transitions?
 - $m = 1 \rightarrow n = 2$
 - $m = 2 \rightarrow n = 3$
 - $n = 2 \rightarrow m = 1$
 - $n = 3 \rightarrow m = 2$
- The intensity of a beam of light is related to its
 - frequency.
 - relative number of photons.
 - speed.
 - wavelength.

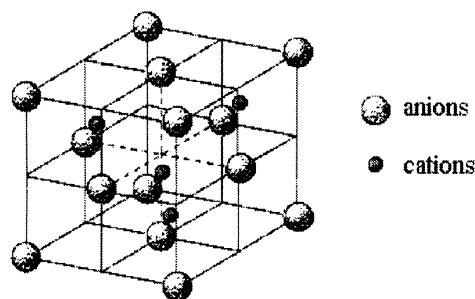
8. Which of the following is *not* a valid set of quantum numbers?
- (A) $n = 2, l = 1, m_l = 0$, and $m_s = -1/2$
(B) $n = 2, l = 1, m_l = -1$, and $m_s = -1/2$
(C) $n = 3, l = 0, m_l = 0$, and $m_s = 1/2$
(D) $n = 3, l = 2, m_l = 3$, and $m_s = 1/2$
9. Consider Li^+ , F^- , and O^{2-} . Which ratio should be the largest?
- (A) (radius O^{2-})/(radius Li^+)
(B) (radius F^-)/(radius Li^+)
(C) (radius Li^+)/(radius O^{2-})
(D) (radius Li^+)/(radius F^-)
10. What is the molecular geometry of BrF_4^- ?
- (A) seesaw
(B) square planar
(C) square pyramidal
(D) tetrahedral
11. What is the hybridization on the N atom in NO_2^- and in NO_3^- ?
- (A) sp^2 for NO_2^- and sp^3 for NO_3^-
(B) sp^3 for NO_2^- and sp^2 for NO_3^-
(C) sp for NO_2^- and sp^2 for NO_3^-
(D) sp^2 for both
12. Which combination always results in a reaction being spontaneous?
- (A) ΔH is positive and ΔS is positive.
(B) ΔH is positive and ΔS is negative.
(C) ΔH is negative and ΔS is positive.
(D) ΔH is negative and ΔS is negative.
13. Given three cylinders containing O_2 gas at the same volume and pressure. Cylinder A is at -20°C , cylinder B is at -15°F , cylinder C is at 260 K. Which cylinder contains the largest mass of oxygen?
- (A) cylinder A;
(B) cylinder B;
(C) cylinder C;
(D) All cylinders contain the same mass of O_2 .
14. A 0.500 g sample containing Ag_2O and inert material is heated, causing the silver oxide to decompose according to the following equation:
- $$2 \text{Ag}_2\text{O}(s) \rightarrow 4 \text{Ag}(s) + \text{O}_2(g)$$
- If 13.8 mL of gas are collected over water at 27°C and 1.00 atm external pressure, what is the percentage of silver oxide in the sample? The partial pressure of water is 26.7 mm Hg at 27°C .
- (A) 12.5%;
(B) 25.1%;
(C) 50.1%;
(D) 51.9%

15. The plots below represent vapor pressure vs. temperature curves for diethyl ether, ethanol, mercury, and water, not necessarily in that order.



Based on the relative strengths of the intermolecular forces of attraction of each substance, which is the most likely vapor pressure vs. temperature curve for diethyl ether?

- (A) curve (a);
 (B) curve (b);
 (C) curve (c);
 (D) curve (d)
16. A certain mineral crystallizes in the cubic unit cell shown below.



What kind of packing do the anions adopt?

- (A) body-centered cubic;
 (B) cubic closest packed (face-centered cubic);
 (C) hexagonal closest packed;
 (D) simple cubic
17. Followed previous question, how many cations and how many anions are in the unit cell?
- (A) 4 cations and 4 anions;
 (B) 4 cations and 8 anions;
 (C) 4 cations and 14 anions;
 (D) 8 cations and 4 anions

Answer: A

18. Which cation in each set is expected to have the larger (more negative) hydration energy?

I. Mg^{2+} or Ba^{2+}

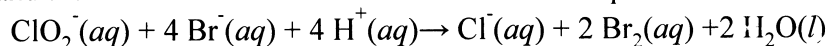
II. K^{+} or Al^{3+}

- (A) Mg^{2+} in set I and K^{+} in set II;
 (B) Mg^{2+} in set I and Al^{3+} in set II;
 (C) Ba^{2+} in set I and K^{+} in set II;
 (D) Ba^{2+} in set I and Al^{3+} in set II

19. When ethylene glycol, HOCH₂CH₂OH, is added to the water in an automobile radiator, the effect is to

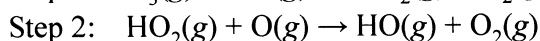
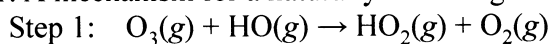
- (A) lower the boiling point and lower the freezing point.
- (B) lower the boiling point and raise the freezing point.
- (C) raise the boiling point and lower the freezing point.
- (D) raise the boiling point and raise the freezing point.

20. For the reaction shown below, what is the relationship between the rate of formation of Br₂ and the rate of reaction of Br⁻ over the same time period?



- (A) rate of formation of Br₂ = 1/2 × rate of reaction of Br⁻;
- (B) rate of formation of Br₂ = 1/4 × rate of reaction of Br⁻;
- (C) rate of formation of Br₂ = 2 × rate of reaction of Br⁻;
- (D) rate of formation of Br₂ = 2 × rate of reaction of Br⁻

21. A mechanism for a naturally occurring reaction that destroys ozone is:



Which species is a catalyst?

- (A) HO;
- (B) HO₂;
- (C) O;
- (D) O₃

22. Which one of the following statements does not describe the equilibrium state?

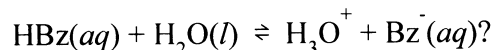
- (A) Equilibrium is dynamic and there is no net conversion to reactants and products.
- (B) The concentration of the reactants is equal to the concentration of the products.
- (C) The concentration of the reactants and products reach a constant level.
- (D) The rate of the forward reaction is equal to the rate of the reverse reaction.

23. For the reaction: N₂(g) + 2 O₂(g) ⇌ 2 NO₂(g), K_c = 8.3 × 10⁻¹⁰ at 25°C.

What is the concentration of N₂ gas at equilibrium when the concentration of NO₂ is five times the concentration of O₂ gas?

- (A) 3.3 × 10⁻¹¹ M;
- (B) 1.7 × 10⁻¹⁰ M;
- (C) 6.0 × 10⁹ M;
- (D) 3.0 × 10¹⁰ M

24. Benzoic acid (C₆H₅CO₂H = HBz) solutions are sometimes used in experiments to determine the molarity of a basic solution of unknown concentration. What is the pH of a 0.100 M solution of benzoic acid if K_a = 6.5 × 10⁻⁵ and the equilibrium equation of interest is



- (A) 1.00;
- (B) 2.59;
- (C) 4.19;
- (D) 5.19

25. What is the pH of a solution made by mixing 30.00 mL of 0.10 M acetic acid with 40.00 mL of 0.10 M KOH? Assume that the volumes of the solutions are additive. $K_a = 1.8 \times 10^{-5}$ for $\text{CH}_3\text{CO}_2\text{H}$.
- (A) 8.26;
 (B) 9.26;
 (C) 11.13;
 (D) 12.15
26. For the substitution reactions $\text{trans}[\text{Pt}(\text{PEt}_3)_2\text{LCl}] + \text{py} \rightarrow \text{trans}[\text{Pt}(\text{PEt}_3)_2\text{L}(\text{py})]^+ + \text{Cl}^-$, which of the following *trans* ligand **L** will make the reaction fastest?
- (A) OH^-
 (B) Br^-
 (C) CH_3^-
 (D) CN^-
27. The color of which of the following species is due to charge-transfer?
- (A) $\text{Mn}^{2+}_{(\text{aq})}$
 (B) KMnO_4
 (C) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
 (D) Fe_3O_4
28. Which of the following complexes is most likely to be low spin?
- (A) CoCl_6^{4-}
 (B) $\text{Co}(\text{H}_2\text{O})_6^{2+}$
 (C) $\text{Co}(\text{NH}_3)_6^{2+}$
 (D) CoF_6^{4-}
29. Which one is isolobol with CH_3^+ ?
- (A) $\text{Mn}(\text{CO})_5^+$
 (B) $\text{Mn}(\text{CO})_6^+$
 (C) $\text{Cr}(\text{CO})_5^+$
 (D) $\text{Cr}(\text{CO})_6^+$
30. Classify the cluster structure type of $\text{C}_2\text{B}_3\text{H}_7$ is ?
- (A) hypho
 (B) arachno
 (C) closo
 (D) nido

II. 問答與計算題：

1. 10 % Explain the following terms
 - i. Ideal solution
 - ii. Second law of thermodynamics
 - iii. Henry's Law
 - iv. Definition of entropy
 - v. Van der waals equation

2. 10% A sample of 4.0 mol N_2 is originally confined in 20 L at 400 K and undergo adiabatic expansion against a constant external pressure of 760 torr until the volume has increased to 40 L. Calculated the internal energy change (ΔU) and work (w) = ?

3. 5% Draw a P-T phase diagram of pure CO_2 .

4. 15% Determine the LFSE for each of following item (don't consider $J-T$ effect)
 - (A) $[Fe(CN)_6]^{4-}$ (B) $[Fe(H_2O)_6]^{3+}$ (C) $[CoCl_4]^{2-}$ (tetrahedral)
 - (D) $[Cr(NH_3)_6]^{3+}$ (E) $[Ru(NH_3)_6]^{3+}$