

You may find the following information useful:

Speed of light in vacuum	$3 \times 10^8 \text{ m s}^{-1}$
Planck constant	$6.626 \times 10^{-34} \text{ J s}$
Boltzmann constant	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Electron mass	$9.11 \times 10^{-31} \text{ kg}$
Proton mass	$1.67 \times 10^{-27} \text{ kg}$
Avogadro constant	$6.02 \times 10^{23} \text{ mol}^{-1}$
Gas constant	$0.08206 \text{ L-atm/mol-K}$

1 atm = 101325 Pa

Van der Waals constants for

$\text{CO}_2(\text{g})$: $a = 3.59 \text{ L}^2\text{-atm/mol}^2$, $b = 0.0427 \text{ L/mol}$

$\text{O}_2(\text{g})$: $a = 1.36 \text{ L}^2\text{-atm/mol}^2$, $b = 0.0318 \text{ L/mol}$

Chloroform: Normal freezing point = $-63.5 \text{ }^\circ\text{C}$, $K_f = 4.68 \text{ }^\circ\text{C/m}$

Water: Normal freezing point = $0.0 \text{ }^\circ\text{C}$, $K_f = 1.86 \text{ }^\circ\text{C/m}$

Water: Normal boiling point = $100.0 \text{ }^\circ\text{C}$, $K_b = 0.51 \text{ }^\circ\text{C/m}$

K_{sp} of $\text{Pd}(\text{OH})_2$ at 298 K = 3×10^{-28}

Standard potential of reaction $\text{Pd}^{2+} + 2\text{e}^- \rightarrow \text{Pd}_{(s)}$ = 0.915 V

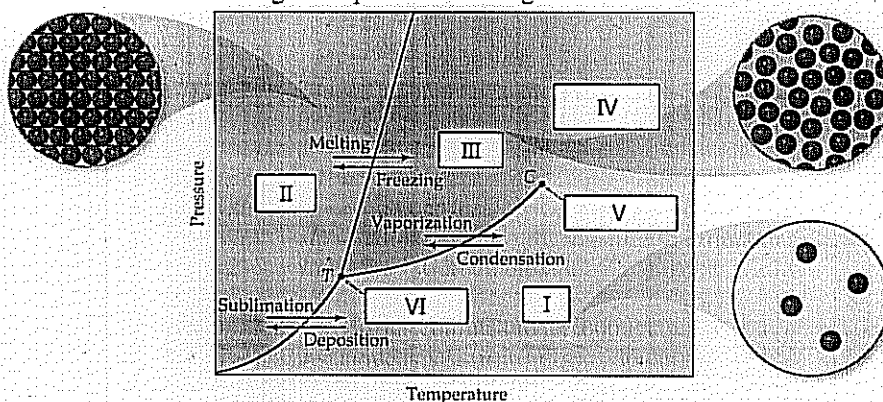
Standard reduction potential of silver chloride electrode (saturated) = 0.197 V

單選題，每題答對2分，答錯0分。

- Which of the following statement is correct:
 - Robert Boyle – The volume of a fixed quantity of gas maintained at constant is proportional to the pressure
 - Amedeo Avogadro – Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules
 - Evangelista Torricelli – The height of the mercury barometer column is a measure of atmospheric pressure and does not change as atmospheric pressure changes
 - Rudolf Clausius – The ideal-gas equation could be corrected to account for the effects of intermolecular attractive forces and for molecular volumes
 - Thomas Graham – The effusion rate of a gas is proportional to the square root of its molar mass
- Why is pH = 7 considered neutral pH?
 - because $K_w = 10^{-14}$
 - because Dr. Lewis defined it this way
 - because $[\text{H}^+] = 10^{-7}$
 - because pH scale usually goes from 0 to 14
 - None of the above

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3. If we add 1 mole of HCl gas to 1 L D₂O (deuterium oxide, or heavy water), what is [D⁺] in this solution?
A. 0.9 to 1 M
B. 0.3 to 0.7 M
C. >1.5 M
D. 0.01 to 0.1 M
E. 1.01 M
4. Consider the half reaction
 $\text{As}_{(s)} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{AsH}_{3(g)} \quad E^{\circ} = -0.238 \text{ V}$
Calculate E at 298 K when pH = 3.00 and P_{AsH₃} = 1.00 torr.
A. -0.359 V
B. 0.359 V
C. -0.119 V
D. 0.119 V
E. -0.238 V
5. The critical temperatures of argon, methane, carbon dioxide, ammonia, and hydrogen sulfide, are in the order of
A. Methane < Ammonia < Hydrogen sulfide < Argon < Carbon dioxide
B. Hydrogen sulfide < Argon < Methane < Ammonia < Carbon dioxide
C. Ammonia < Methane < Hydrogen sulfide < Carbon dioxide < Argon
D. Argon < Methane < Carbon dioxide < Hydrogen sulfide < Ammonia
E. Methane < Argon < Ammonia < Carbon dioxide < Hydrogen sulfide
6. A sample of 1.000 mol of CO₂(g) is confined to a 3.000 L container at 0.000 °C. What is the pressure of this gas when: (i) CO₂(g) is an ideal gas; (ii) CO₂(g) is not an ideal gas.
A. Case (i) - The gas pressure = 756 atm; Case (ii) - The gas pressure = 767 atm
B. Case (i) - The gas pressure = 7.47 atm; Case (ii) - The gas pressure = 7.48 atm
C. Case (i) - The gas pressure = 7.47 atm; Case (ii) - The gas pressure = 7.18 atm
D. Case (i) - The gas pressure = 7.47 atm; Case (ii) - The gas pressure = 7.42 atm
E. Case (i) - The gas pressure = 756 atm; Case (ii) - The gas pressure = 7.24 atm
7. Which of the following description for the diagram is correct:



- A. I : Liquid, II : Solid, III : Gas, V : Contact point, VI : Transition point
B. I : Gas, II : Solid, III : Liquid, IV : Supercritical fluid, V : Critical point
C. I : Gas, II : Solid, III : Liquid, IV : Superheating fluid, VI : Tricky point
D. I : Gas, II : Solid, III : Liquid, V : Conversion point, VI : Transmission point

題號：2031

題號：2031

科目：普通化學甲

共 3 頁之第 3 頁

E. I : Gas, II : Liquid, III : Solid, IV : Supercooling fluid, VI : Technical point

8. For each of the following classes which metal would you expect to have the highest melting point:

Class I: Rubidium (Rb), Indium (In), Molybdenum (Mo)

Class II: Strontium (Sr), Ruthenium (Ru), Cadmium (Cd)

Class III: Yttrium (Y), Niobium (Nb), Zirconium (Zr)

Class IV: Gold (Au), Cesium (Cs), Rhenium (Re)

A. Class I: Mo, Class II: Ru, Class III: Nb, Class IV: Re

B. Class I: Mo, Class II: Cd, Class III: Nb, Class IV: Au

C. Class I: In, Class II: Sr, Class III: Y, Class IV: Cs

D. Class I: Rb, Class II: Ru, Class III: Zr, Class IV: Au

E. Class I: In, Class II: Cd, Class III: Y, Class IV: Re

9. The solubilities of different gases: N₂, Kr, CO, Ar, O₂ in water at 20 °C, with 1 atm gas pressure, are in the order of

A. Kr < Ar < O₂ < N₂ < CO

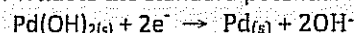
B. CO < N₂ < Ar < Kr < O₂

C. N₂ < O₂ < CO < Kr < Ar

D. N₂ < O₂ < CO < Ar < Kr

E. N₂ < CO < O₂ < Ar < Kr

10. What is the standard potential for the reaction below



A. -0.202 V

B. 0.202 V

C. -0.101 V

D. 0.101 V

E. None of the above

11. If a reduction potential of +0.530 V is obtained with reference to Ag/AgCl (saturated KCl), which of the following is an alternative but equivalent representation of the result?

A. +0.530 V versus SHE

B. +0.727 V versus SHE

C. +0.333 V versus SHE

D. -0.333 V versus SHE

E. -0.727 V versus SHE

12. Which of the following is an extensive property?

A. Critical temperature

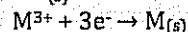
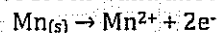
B. Entropy

C. Molar heat capacity

D. Specific heat capacity

E. Boiling point

13. An electrolysis cell is fitted with the Mn and Pt electrodes. Assume that the cell initially contain 0.025 M of Mn²⁺ and another metal ion (M³⁺) such that the reactions at the electrodes are



If a constant current of 2.60 A is passed through the cell for 18.0 min, 0.504 g of the metal (M) would plate out on the Pt electrode. What is the atomic weight of M?

A. 23.0 g/mole

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- B. 42.0 g/mole
- C. 46.0 g/mole
- D. 52.0 g/mole
- E. 17.3 g/mole

14. For a $[H^+]$ concentration of 0.0000836 M, the pH value should be written as

- A. 4.08
- B. 4.078
- C. 4.1
- D. 4.0778
- E. 4.07779

複選題，每題全部答對4分，答錯一選項2.4分，答錯二選項0.8分，答錯三選項或以上者0分。

15. If a pH indicator changes color around pH 3 to 5, then which of the following is impossible:

- A. its pKa may be 3.8
- B. its pKb may be 8.8
- C. this indicator is good for a weak-acid-strong-base titration
- D. we can add a lot of this indicator to make a buffer solution with pH 3.8
- E. this indicator is a weak base

16. Lithium metal, which has a work function of 279.7 kJ/mol, was used in photoelectric effect study. Which of the following statements are correct?

- A. The energy of each incident photon must be higher than 4.6×10^{-19} J to eject an electron from Li metal.
- B. By increasing the energy of incident light, the photocurrent is increased.
- C. To eject an electron from Li, the frequency of the incident light must be higher than 7.01×10^{11} Hz.
- D. To eject an electron from Li, the wavelength of the incident light must be shorter than 427 nm.
- E. Electrons ejected with higher energy photon have longer de Broglie wavelength.

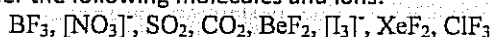
17. Which of the following descriptions about an atom or ion are correct?

- A. The 1s orbital size: $He^+ < H$
- B. Orbital size: $1s < 2s < 3s$
- C. Orbital energy in Li^{2+} : $3s < 3p < 3d$
- D. Penetration ability of orbital: $s > p > d$
- E. The energy difference in H atom: $\Delta E(3s - 1s) = -1.45 \times 10^{-18}$ J

18. Which of the following descriptions of elements are correct?

- A. In Be atom, the effective nuclear charge felt by the 1s electrons and 2s electrons is identical.
- B. Fluorine is the most electronegative element.
- C. Oxygen atom has smaller first ionization energy than nitrogen atom because oxygen is larger in size.
- D. Both Si and Ge are metalloids.
- E. Chlorine has the highest electron affinity.

19. Consider the following molecules and ions:



Which of the following descriptions are correct?

- A. There are four linear molecules/ions
- B. $[\text{NO}_3]$ has three resonance structures which can be individually isolated
- C. There are three molecules/ions containing a sp^2 hybrid central atom
- D. BF_3 , BeF_2 , XeF_2 and ClF_3 are non-polar molecules
- E. All of the non-polar molecules contain non-polar bonds

20. Which of the following statements are correct?

- A. H_2 is more stable than $[\text{H}_2]^+$
- B. O_2 is diamagnetic (no unpaired electron)
- C. The O-O bond length in O_2 is shorter than that in $[\text{O}_2]^+$
- D. N_2 has higher bond order than O_2
- E. $[\text{NO}]^+$ is more stable than $[\text{NO}]^-$

21. A compound, XF_5 , contains 72.82% of fluorine by weight. Which of the following statements are correct?

- A. This molecule is PF_5
- B. This is a polar molecule
- C. This molecule does not contain polar bonds
- D. The hybridization of X is dsp^3
- E. Geometry of this molecule is square pyramidal

22. Which of the following descriptions are correct?

- A. Molecular orbital is equivalent to hybrid orbital.
- B. Two s orbitals will overlap to form one molecular orbital.
- C. No more than two electrons can occupy one molecular orbital.
- D. Overlap of two p orbitals always leads to the formation of a π bond.
- E. Bonding molecular orbital has high electron density between nuclei.

23. Which of the following descriptions are correct?

- A. Lattice energy is the energy required to separate one mole of a solid ionic compound into its gaseous ions.
- B. The lattice energy of LiF is larger than NaCl .
- C. A chemical bond formed by sharing a pair of electrons is a covalent bond.
- D. Polar molecules must contain polar bonds.
- E. HF has larger dipole moment than HBr .

24. For hydrogen atom, the radial wave function for $n = 3$ and $l = 1$ orbital is

$$\psi_{3,1} = \frac{4}{81\sqrt{6}} \left(\frac{1}{a_0}\right)^{3/2} (6\sigma - \sigma^2)e^{-\sigma/3}$$

where $\sigma = r/a_0$ and a_0 is the Bohr radius (0.529Å). Which of the following statements are correct?

- A. This is the wave function of 3s orbital
- B. This orbital has two lobes separated by a node at the nucleus
- C. There are two nodes.
- D. There is no electron density at $r = 1.587 \text{ \AA}$
- E. There is no electron density at $r = 3.174 \text{ \AA}$

25. Which kind of intermolecular interaction present in this solution: 1.0 M $\text{CH}_3\text{CH}_2\text{OH}$ in water

- A. Dispersion force
- B. Hydrogen bonding

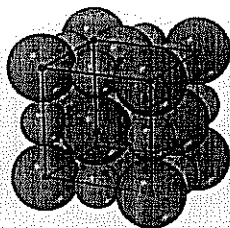
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- C. Dipole-dipole force
- D. Ionic bonding
- E. All of the above

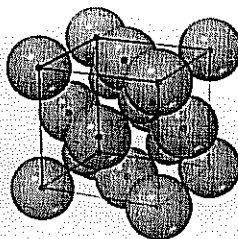
26. For any spontaneous chemical reactions in a beaker at constant temperature and pressure, which of the following condition must be satisfied?

- A. $\Delta S_{\text{system}} \geq 0$
- B. $\Delta H - T\Delta S_{\text{system}} < 0$
- C. $\Delta G < 0$
- D. $\Delta S_{\text{universe}} < 0$
- E. $\Delta U - T\Delta S_{\text{system}} < 0$

27. Which of the following statements regarding NaCl and ZnS crystal structures are correct:



NaCl structure



ZnS structure

- A. They are both face-centered cubic lattice
 - B. The cation coordination number is 6 in the NaCl structure
 - C. The anion coordination number is 6 in the NaCl structure
 - D. The cation coordination number is 4 in the ZnS structure
 - E. The anion coordination number is 8 in the ZnS structure
28. The average osmotic pressure of blood is 7.7 atm at 25 °C. What concentration of glucose (M. W. 180.16 g/mol) will be isotonic with blood? (Water and glucose solution both have a density of 1.00 g/mL)
- A. ~ 0.31 M
 - B. ~ 5.6 wt %
 - C. ~ 0.33 m
 - D. ~ 0.052 ppm
 - E. None of the above is correct
29. Which of the following statements regarding the freezing and boiling points of these solutions are correct:
- Solution I: 0.240 mol naphthalene in 2.45 mol of chloroform (M.W. = 119.4 g/mol)
- Solution II: 1.50 g NaCl (M.W. = 58.44 g/mol) in 250 g of water
- Solution III: 2.04 g KBr (M.W. = 119.0 g/mol) and 4.82 g glucose in 188 g of water
- A. The freezing point of Solution I is -67.3 °C
 - B. The boiling point of Solution II is 100.1 °C
 - C. The freezing point of Solution III is -0.6 °C
 - D. The boiling point of Solution III is 100.2 °C
 - E. None of the above is correct
30. Which of the following descriptions about the atomic spectrum of hydrogen atom are correct?
- A. The atomic spectrum of hydrogen atom is a continuous spectrum.

題號：2031

題號：2031

科目：普通化學甲

共 7 頁之第 7 頁

- B. The energy required to remove the electron from a ground state hydrogen atom is 2.178×10^{-18} J.
 C. The first excitation means to move an electron from $n = 1$ to $n = 2$.
 D. Transition from 2s to 1s emits a photon of wavelength 102 nm
 E. Transition of electron from 3p to 1s releases more energy than transition from 3s to 1s.

31. For the reaction $2 \text{NO}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{NOCl}(\text{g})$ described in the following Table, which of the following statements are correct?

Table 13.2 Initial Rates of the Reaction $2 \text{NO}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{NOCl}(\text{g})$			
Experiment	Initial [NO]	Initial [Cl ₂]	Initial Rate, M s^{-1}
1	0.0125 M	0.0255 M	2.27×10^{-5}
2	0.0125 M	0.0510 M	4.55×10^{-5}
3	0.0250 M	0.0255 M	9.08×10^{-5}

- A. The initial rate for the condition of $[\text{NO}] = 0.0500 \text{ M}$ and $[\text{Cl}_2] = 0.0255 \text{ M}$ is $18.16 \times 10^{-5} \text{ M s}^{-1}$
 B. The initial rate constant of the reaction cannot be determined
 C. The reaction is first order with respect to $[\text{Cl}_2]$
 D. The reaction is considered as an elementary reaction
 E. The entropy change of the reaction favors the formation of NOCl
32. Consider the reaction $A \rightleftharpoons B$. Given that the ΔG° of this reaction is zero, which of the following statements are correct?
- A. At equilibrium, the system will contain A only
 B. The equilibrium constant is equal to 1
 C. The Gibb's free energy of the system is at minimum when the amount of A and B are the same
 D. At equilibrium, the system will contain B only
 E. For a more negative ΔG° , the formation of B is more favorable

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