＊請在答案卷上標明題號依序作答
- Atmic mass: H = 1.01, He = 4.00, C = 12.0, O = 16.0, N = 14.0, Cl = 35.5 Na = 23.0
- Gas constant: R = 8.314 J/mol-K = 0.0821 L-atm/mol-K
- C = 3.00×10^8 m/s; h = 6.63×10^{-34} J-s; R_H = 1.097×10^7 m^{-1}; F = 96500 C/mol

I. 選擇題 （90%, 每題 3 分，單選與多重選混合，每題答案可能 1 至多個，全部選對始得題分 3 分）

1. A typical commercial-grade hydrochloric acid is 38% HCl by mass and density 1.18 g/mL. Calculate the molarity (mol/L) of the acid.
   (A) 18 M   (B) 15 M   (C) 12 M   (D) 10 M

2. What volume of 0.1022 M H_2SO_4(aq) is required to neutralize 25.00 mL of 0.1182 M NaOH?
   (A) 57.83 mL   (B) 28.91 mL   (C) 21.62 mL   (D) 14.46 mL

3. At 27°C and 760 mmHg, both a 16.0 g sample of methane gas (CH_4) and a 32.0 g sample of oxygen gas (O_2) will have the same:
   (A) number of gaseous particles   (B) total gaseous volumes
   (C) average molecular kinetic energies   (D) root-mean-square speeds

4. Halothane is one of the modern anesthetics which is nonflammable and relatively safe for patients. What is the molar mass of halothane if 456 milligrams is 52.8 milliliters at 22°C and 805 torr?
   (A) 197 g/mol   (B) 209 g/mol   (C) 221 g/mol   (D) 1.06×10^3 g/mol

5. For the following types of electromagnetic radiation: UV, microwave, IR, and visible which of the following ranking is correct?
   (A) Speed under vacuum: UV > visible > IR > microwave
   (B) Wavelength: UV > visible > IR > microwave
   (C) Frequency: UV > visible > IR > microwave
   (D) Energy: UV > visible > IR > microwave

6. How many orbitals have the values n = 3, ℓ = 1, and m_ℓ = 0?
   (A) 0   (B) 1   (C) 3   (D) 9

7. Which of the following orbital diagram is correct for the **ground-state** electron configuration?
   (A) ↑↓ ↑↓ ↑ ☐ ☐ (B) ↑↓ ↑↓ ↓ ↓ ↓ (C) ↑↓ ↑ ↑ ↑ ↑ (D) ↑↓ ↑↓ ↑ ☐ ↑
   1s 2s   2p   1s 2s   2p   1s 2s   2p   1s 2s   2p

8. Which of the following ranking is correct?
   (A) Ionic radius: P^{3-} > S^{2-} > Cl^- (B) Atomic radius: Na > Mg > Al
   (C) First ionization energy: N > O > F   (D) Electronegativity: F > Cl > Br

9. Which of the following species would you expect to be diamagnetic?
   (A) Ca   (B) Al   (C) Fe   (D) Zn

10. Which of the following molecules would you expect to have a resultant dipole moment (μ)?
    (A) ClF_3 (B) BF_3 (C) AsH_3 (D) SO_3

11. The structure of crystalline sodium chloride is shown as figure. How many Na^+ ions are in each NaCl unit cell?
    (A) 1   (B) 4   (C) 8   (D) 13

Cl⁻
Na⁺
Sodium chloride

12. Which one of the following substances would have hydrogen bonding as one of its intermolecular forces?
    (A) CH_3CONH_2 (B) NH_4^+ (C) C_6H_5OH (D) CH_3COOCH_3

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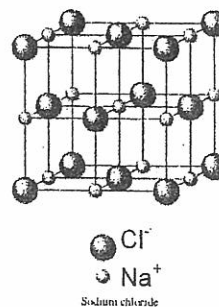
13. For the following substances: C_3H_8, CH_3OCH_3, and C_2H_5OH, choose the correct ranking.

(A) van der Waals forces: $C_3H_8 < CH_3OCH_3 < C_2H_5OH$

(B) vapor pressure at same temperature: $C_3H_8 < CH_3OCH_3 < C_2H_5OH$

(C) normal boiling point: $C_3H_8 < CH_3OCH_3 < C_2H_5OH$

(D) enthalpy of vaporization: $C_3H_8 < CH_3OCH_3 < C_2H_5OH$

14. Isotonic saline solution can be prepared by dissolving 0.923 g of NaCl in enough water to produce 100. mL of solution. What is the osmotic pressure of this solution at 25 °C?

(A) 0.363 atm　　(B) 0.726 atm　　(C) 3.86 atm　　(D) 7.71 atm

15. Choose the one that is weak base.
(A) CH_3NH_2　　(B) NH_4^+　　(C) C_6H_5OH　　(D) NaOH

16. Which of the following is conjugated acid-base pair?
(A) $HClO_3$, $HClO_4$　　(B) H_3O^+, OH^-　　(C) HSO_3^-, SO_3^{2-}　　(D) H^+, H^-

17. Solubility rules predict precipitate formation for mixing 0.1 M aqueous solutions of
(A) Na_2SO_4, $Ba(NO_3)_2$　　(B) NaCl, $Pb(NO_3)_2$　　(C) HCl(aq), $Hg(NO_3)_2$　　(D) $(NH_4)_2S$, $AgNO_3$

18. The following titration curve is obtained as part of a general chemistry laboratory experiment for an unknown.

(A) The titrant is a strong acid.

(B) The analyte is a strong base.

(C) The pH value of half-equivalence point is about pH 5.

(D) We shall choose phenolphthalein as the indicator.
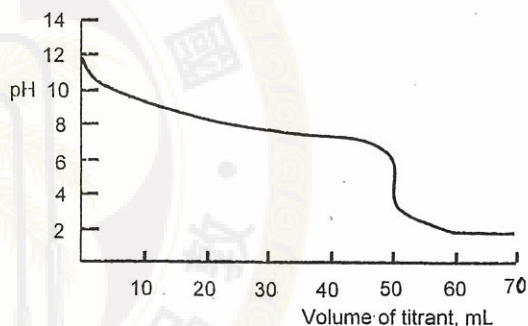
19. In order to prepare a buffer with pH 4.9, which of the following pairs should you choose best?

(A) HCOOH/NaHCOO ($K_a = 1.8 \times 10^{-4}$)

(B) CH_3COOH/$NaCH_3COO$ ($K_a = 1.8 \times 10^{-5}$)

(C) H_2CO_3/$NaHCO_3$ ($K_a = 4.4 \times 10^{-7}$)

(D) NH_4Cl/NH_3 ($K_b = 1.8 \times 10^{-5}$)

20. What is the pH of a solution that is 0.250 M $(CH_3)_3N$(aq)? For trimethylamine, $K_b = 6.3 \times 10^{-5}$.

(A) 2.40　　(B) 4.20　　(C) 9.80　　(D) 11.60

21. What is the molar solubility of AgBr(s) in 3.0 M NH_3(aq)?

K_{sp} of AgBr(s) is 5.0×10^{-13}, K_f of $Ag(NH_3)_2^+$ is 1.6×10^7.

(A) 7.1×10^{-7} M　　(B) 8.4×10^{-3} M　　(C) 4.0×10^3 M　　(D) none of the above

22. The data are obtained for the reaction:

$2HgCl_2(aq) + C_2O_4^{2-}(aq) \rightarrow 2Cl^-(aq) + 2CO_2(g) + Hg_2Cl_2(s)$

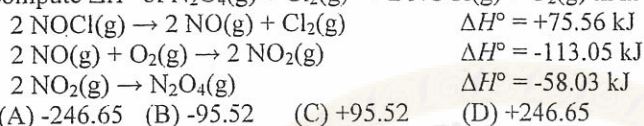| Experiment	$[HgCl_2]$, M	$[C_2O_4^{2-}]$, M	Initial rate, M/min
1	0.105	0.15	1.8×10^{-5}
2	0.105	0.30	7.1×10^{-5}
3	0.052	0.30	3.5×10^{-5}

(A) The reaction order with respect to $HgCl_2$ is 2.

(B) The reaction order with respect to $C_2O_4^{2-}$ is 1.

(C) The value of rate constant k is 7.6×10^{-3}.

(D) If $[C_2O_4^{2-}] = 0.15$ M and $[HgCl_2] = 0.052$ M, the initial rate would be 8.9×10^{-6} M/min.

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23. For a **first** order reaction: A → P, the following data were obtained.

Time (min.)	[A] (M)
0.0	0.800
18.0	0.400
36.0	0.200
54.0	0.100

(A) A plot of 1/[A] versus time is linear.

(B) The half life for the reaction is 18 min.

(C) The rate constant for the reaction is 0.0385 min^{-1}.

(D) It takes 90 min. to decrease the concentration of A to 0.025 M

24. Compute ΔH^o of $N_2O_4(g) + Cl_2(g) \rightarrow 2 NOCl(g) + O_2(g)$ in kJ according to the following reactions.

$2 NOCl(g) \rightarrow 2 NO(g) + Cl_2(g)$ $\Delta H^o = +75.56$ kJ

$2 NO(g) + O_2(g) \rightarrow 2 NO_2(g)$ $\Delta H^o = -113.05$ kJ

$2 NO_2(g) \rightarrow N_2O_4(g)$ $\Delta H^o = -58.03$ J

(A) -246.65   (B) -95.52   (C) +95.52   (D) +246.65

25. Consider the decomposition of barium carbonate: $BaCO_3(s) \rightarrow BaO(s) + CO_2(g)$.

At 298 K, $\Delta H^o = +268$ kJ, $\Delta S^o = +172.4$ J

(A) This is an endothermic reaction.

(B) The entropy of the system increases.

(C) The reaction is spontaneous at 298 K.

(D) The equilibrium constant of the reaction is increasing with increasing temperature.

26. For the Haber process at 25°C, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$\Delta H^o = -92$ kJ, $\Delta S^o = -198$ J/K, and $\Delta G^o = -33$ kJ. Calculate equilibrium constant, K, at 298 K.

(A) 1.0   (B) 6.1×10^5 (C) 1.3×10^{16} (D) 8.9×10^{68}

27. According to the cell diagram: Pt(s) | H_2(g) | H^+(aq) ‖ Cu^{2+}(aq) | Cu(s)
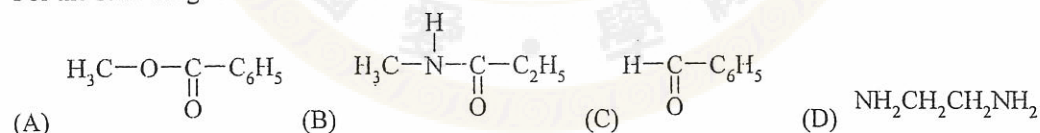
(A) Pt(s) undergoes oxidation.   (B) Cu(s) is the cathode.

(C) Electrons flow from Pt(s) to Cu(s).   (D) Cu^{2+} is the oxidant.

28. At 298 K, a voltaic cell with E_{cell} = 0.180 V, is constructed as follows:

Ag(s) | Ag^+ (satd. Ag_3PO_4) ‖ Ag^+(0.140 M) | Ag(s).   What is the K_{sp} of Ag_3PO_4?

(A) 1.3×10^{-4} (B) 1.7×10^{-8} (C) 2.9×10^{-16} (D) 9.5×10^{-17}

29. For the following molecules choose the one that is an amide?

(A)   (B)   (C)   (D) $NH_2CH_2CH_2NH_2$

30. Which of the following nuclide is radioactive?

(A) $^{235}_{92}U$ (B) $^{244}_{94}Pu$ (C) $^{131}_{53}I$ (D) $^{14}_{6}C$

II. 計算問答題 (10%)

31. For the complex ion $[Co(en)_3]^{3+}$, ethylenediamine (en) is a strong field ligand.

(A) Give the oxidation state and coordination number of central metal ion.

(B) Write the electron configurations of the central metal ion.

(C) What's the geometry of the complex ion?

(D) Draw the crystal-field energy-level diagrams and show the placement of electrons for the complex.

(E) Is the complex ion diamagnetic or paramagnetic?

試題隨卷繳回