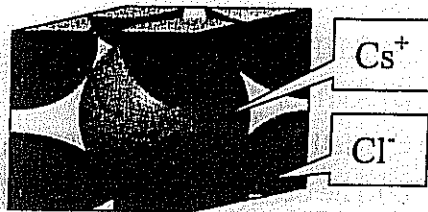※ 注意：選擇題請於答案卷之「選擇題作答區」依序作答。

- Gas constant: $R = 8.314$ J/mol-K = 0.0821 L-atm/mol-K
- Atmic mass: H = 1.01, He = 4.00, C = 12.01, O = 16.00, N = 14.01, Cl = 35.5 Na = 22.99, K = 39.10
- $C = 3.00 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J-s; 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. Which of the following conversion is correct?
   (A) -196°C = 77 K   (B) 0.15 g = 15 mg   (C) 15 torr = 15 cmHg   (D) 74 pm = 7.4×10^{-2} nm

2. A typical commercial-grade acetic acid is 36% CH_3COOH by mass and density 1.05 g/mL. Calculate the molarity (mol/L) of the CH_3COOH.
   (A) 6.3 M   (B) 12 M   (C) 17 M   (D) 18 M

3. An unknown concentration of NaOH solution is standardized with potassium hydrogen phthalate (KHP, $KHC_8H_4O_4$).   It uses 15.50 mL of NaOH solution to neutralize 0.4084 g of KHP. Which of the following statements are true?
   (A) KHP is a monoprotic acid.
   (B) KHP is a weak acid.
   (C) Methyl red ($K_a = 1 \times 10^{-5}$) is a suitable indicator for the titration.
   (D) The determined concentration of NaOH is 0.1290 M.

4. A quantity of 4.00×10^2 mL of 0.600 M HNO_3 is mixed with 4.00×10^2 mL of 0.300 M $Ba(OH)_2$ in a constant-pressure calorimeter of negligible heat capacity.   The initial temperature of both solutions is the same at 20.50 $^\circ$C, and the final temperature of the solution is 24.50 $^\circ$C. Calculate the molar heat of neutralization. Assume the density and specific heat capacity of aqueous solution is same as water (1.00 g/mL and 4.184 J/g-$^\circ$C, respectively).
   (A) -55.8 kJ/mol   (B) -27.9 kJ/mol   (C) -26.7 kJ/mol   (D) -13.4 kJ/mol

5. For the reaction: $2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$, which of the following is true?
   (A) H^+ is the catalyst.   (B) MnO_4^- is reduced.
   (C) $C_2O_4^{2-}$ is the oxidizing agent.   (D) The oxidation number of C in $C_2O_4^{2-}$ is +4.

6. The separated sample solutions of an unknown soluble ionic compound are treated with KCl, Na_2SO_4, and NaOH. A precipitate forms only when Na_2SO_4 is added. Which cations could be present in the unknown soluble ionic compound?
   (A) Ba^{2+} (B) Co^{2+} (C) Hg_2^{2+} (D) Pb^{2+}

7. At 298 K and 1 atm, 16.0 g of oxygen gas (O_2) and 16.0 g of helium gas (He) are placed in a container. Both of the gases will have the same:
   (A) number of gaseous particles   (B) partial pressure
   (C) average kinetic energy   (D) root-mean-square velocity

8. How many orbitals have the quantum number values of n = 3 and ℓ = 1?
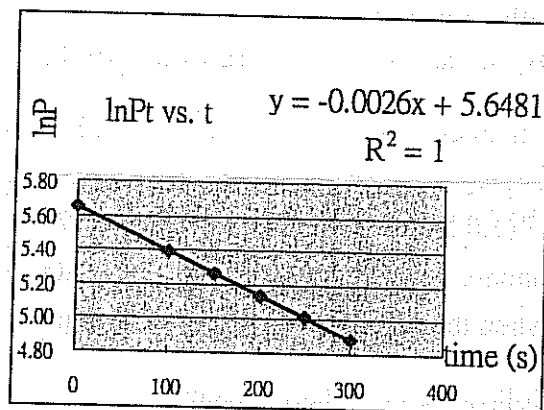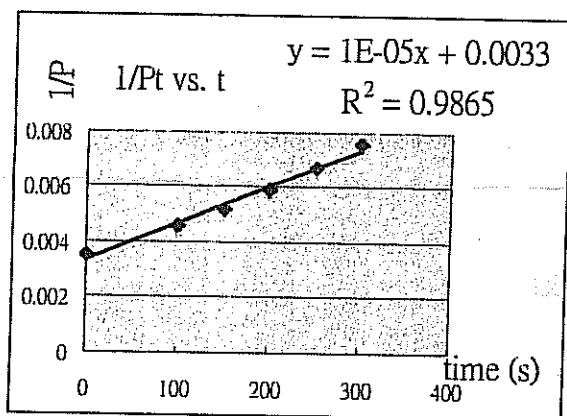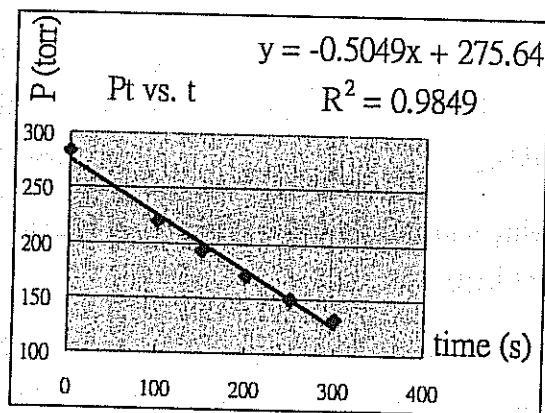   (A) 1   (B) 3   (C) 5   (D) 7

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9. Which of the following orbital diagram is correct for the ground-state electron configuration?

(A) [Ne] ↓↑ ↑ ↑ □   (B) [Ne] ↑↓ ↓ ↓ ↓
    3s   3p   3s   3p

(C) [Ne] ↓ ↓ ↓ ↓   (D) [Ne] ↑↑ ↑ ↑ ↑
    3s   3p   3s   3p

10. Which of the following ranking is correct?

(A) ionic radius: $F^- > Na^+ > Mg^{2+}$ (B) atomic radius: $Li > Na > K$

(C) the first ionization energy: $Li > Na > K$ (D) electronegativity: $F > O > N$

11. Which of the following molecules is linear?

(A) O_3 (B) CO_2 (C) XeF_2 (D) NO_2

12. Which of the following molecules would show dipole-dipole interaction between molecules?

(A) BCl_3 (B) IF_3 (C) PCl_3 (D) CHF_3

13. The structure of crystalline cesium chloride is shown as figure.

(A) There is one Cs^+ ion per unit cell.

(B) There are four Cl^- ions per unit cell.

(C) The ratio of Cs^+ to Cl^- ion is 1/4.

(D) The coordination number of Cs^+ ion is 4.

14. Which one of the following substances would have hydrogen bonding as one of its intermolecular forces?

(A) H_2NCH_2COOH (B) CH_3OH (C) CH_3COCH_3 (D) $CH_3NH_3^+$

15. The safety air bags in automobiles are inflated by nitrogen gas generated by the rapid decomposition of sodium azide, NaN_3: $NaN_3(s) \rightarrow 2 Na(s) + 3 N_2(g)$. If an air bag has a volume of 36 L and is to be filled with nitrogen gas at a pressure of 1.15 atm at a temperature of 27.0 °C, how many grams of NaN_3 must be decomposed?

(A) 0.360 g   (B) 36.5 g   (C) 67.5 g   (D) 109 g   （題幹有誤）

16. Consider the equilibrium: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H^o = 58.0$ kJ/mol, which of the following will shift the equilibrium position to the right?

(A) The volume of container is doubled at constant temperature.

(B) Helium (He) gas is added at constant volume and temperature to increase the total pressure.

(C) The temperature is raised.

(D) A catalyst is added to the system.

17. The rate law for the reaction: $2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$ is rate = $k[H_2][NO]^2$. A suggested mechanism for this reaction is:

Step 1 $2NO + H_2 \xrightarrow{k_1} N_2O + H_2O$ slow

Step 2 $N_2O + H_2 \xrightarrow{k_2} H_2O + N_2$ fast

(A) Step 1 is the rate determining step.

(B) For step 2, it is a bimolecular elementary step.

(C) This is an acceptable mechanism.

(D) N_2O is an intermediate.

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18. The rate of decomposition of azomethane ($C_2H_6N_2$) is studied: $CH_3-N=N-CH_3(g) \rightarrow N_2(g) + C_2H_6(g)$. The data and derived plots obtained at 300°C are shown in the following.

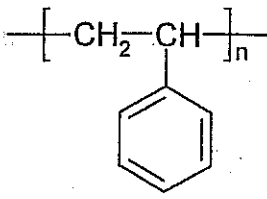(A) This is a second order reaction.

(B) The rate constant of the reaction is -0.0026 s^{-1}.

(C) It takes 267 s to decompose azomethane to 142 torr.

(D) The half-life of this decomposition reaction is dependent on the initial concentration of azomethane.

Time (s)	P_t (torr)	$1/P_t$	$\ln P_t$
0	284	0.00352	5.65
100	220	0.00455	5.39
150	193	0.00518	5.26
200	170	0.00588	5.14
250	150	0.00667	5.01
300	132	0.00758	4.88

Pt vs. t: $y = -0.5049x + 275.64$, $R^2 = 0.9849$

1/Pt vs. t: $y = 1E-05x + 0.0033$, $R^2 = 0.9865$

lnPt vs. t: $y = -0.0026x + 5.6481$, $R^2 = 1$

19. Which of the following statements is true regarding the species in a 1.00 M solution of H_2SO_4?

(A) $[H_2SO_4] \fallingdotseq 0 \text{ M}$ (B) $[HSO_4^-] < 1.00 \text{ M}$ (C) $[SO_4^{2-}] = 1.00 \text{ M}$ (D) $[H^+] = 1.00 \text{ M}$

20. Consider the titration of 25.0 mL of 0.010 M acetic acid (CH_3COOH, $K_a = 1.8 \times 10^{-5}$) by 0.010 M sodium hydroxide solution:

(A) Before titration, the initial pH of 0.010 M CH_3COOH(aq) is 2.00.

(B) After adding 12.5 mL of 0.010 M NaOH to the acid, the pH of the solution is 4.74.

(C) At equivalence point, the pH of the solution is 7.00.

(D) Phenolphthalein ($K_a = 1 \times 10^{-9}$) is an appropriate indicator for the titration.

21. Calculate the pH value of a 0.10 M solution of ammonium chloride (NH_4Cl). K_b of $NH_3 = 1.8 \times 10^{-5}$.

(A) 2.87   (B) 4.87   (C) 5.13   (D) 7.00

22. How many moles of $NaCH_3COO$ must be added to 1.0 L of 0.10 M CH_3COOH to form a buffer whose pH is 5.00? $K_a(CH_3COOH) = 1.8 \times 10^{-5}$.

(A) 0.055 mol   (B) 0.10 mol   (C) 0.18 mol   (D) 0.36 mol

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23. Copper(II) hydroxide, $Cu(OH)_2$, is an insoluble solid with $K_{sp} = 1.0 \times 10^{-20}$ at 25°C. Which of the following is true?
    (A) For $Cu(OH)_2$, $K_{sp} = [Cu^{2+}][OH^-]$.
    (B) The solubility of $Cu(OH)_2$ in water at 25°C is 1.0×10^{-10} M.
    (C) The solubility of $Cu(OH)_2$ will increase in an acidic solution.
    (D) The solubility of $Cu(OH)_2$ will increase in concentrated $NH_3(aq)$.

24. Choose the one with positive entropy change ($\Delta S > 0$) for the reaction.
    (A) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ (B) $I_2(s) \rightarrow I_2(g)$
    (C) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$ (D) $Cu^{2+}(aq) + S^{2-}(aq) \rightarrow CuS(s)$

25. For the following substance, choose the one with $\Delta H_f^o = 0$ (standard enthalpy of formation) at 25°C?
    (A) $O_3(g)$ (B) $I_2(g)$ (C) $Br_2(l)$ (D) $Hg(l)$

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. What is the value of ΔG^o at 500°C. Assume ΔH^o and ΔS^o are constant with temperature.
    (A) -33 kJ   (B) -61 kJ   (C) 61 kJ   (D) 1.5×10^5 kJ

27. For an electrochemical cell that uses Au^{3+}/Au and Ca^{2+}/Ca half-cell reactions under standard conditions and 298 K: $Au^{3+}(1.0 \text{ M}) + 3e^- \rightarrow Au$ $E^0 = 1.50$ V
    $Ca^{2+}(1.0 \text{ M}) + 2e^- \rightarrow Ca$ $E^o = -2.87$ V
    (A) Ca is the anode.   (B) $E^o_{cell} = 11.61$ V.   (C) $\Delta G^o = -2530$ kJ.
    (D) $E_{cell} < 0$, when the reaction reaches equilibrium.

28. Which of the following is chelating agent?
    (A) $C_2O_4^{2-}$ (oxalate ion)   (B) NH_3 (C) $NH_2CH_2CH_2NH_2$ (ethylenediamine)   (D) SCN^-

29. For the polystyrene (PS) with the following structure
    (A) $CH_2=CHC_6H_5$ is the monomer.
    (B) This is a condensation polymer.
    (C) This is polymerized by condensation reaction.
    (D) This is a homopolymer.

$$-\left[CH_2-CH \right]_n-$$

30. For the following molecules choose the one that is an aldehyde?

    (A) $H_2N-C_6H_5$ (B) $\overset{\displaystyle H-\underset{\underset{O}{\|}}{C}-C_6H_5}{}$ (C) $H_3C-O-\underset{\underset{O}{\|}}{C}-C_6H_5$ (D) $H_3C-\underset{\underset{O}{\|}}{C}-C_6H_5$

II. 計算問答題 (10%) ※ 注意：請於答案卷內之「非選擇題作答區」標明題號依序作答。

31. Consider the N_2 molecule and use the molecular orbital model, (a) draw the energy level diagram, (b) write the electron configurations, (c) determine the bond order, and (d) indicate the magnetic property of N_2 (that is diamagnetic or paramagnetic). (e) Compare the bond length with that of N_2^-. (10%)

試題隨卷繳回