

國立高雄大學一百學年度研究所碩士班招生考試試題

科目：普通化學
考試時間：100 分鐘

系所：應用化學系
本科原始成績：100 分

是否使用計算機：是

< I > 單一選擇題(共 25 題，佔 50 分，每題 2 分，答錯不倒扣)

1. A system initially has an internal energy E of 501 J. It undergoes a process during which it releases 111 J of heat energy to the surroundings, and does work of 222 J. What is the final energy of the system, in J?
(A.) 168 J (B.) 390 J (C.) 612 J (D.) 834 J (E.) None of these choices is correct
2. A certain process has $\Delta H^\circ > 0$, $\Delta S^\circ < 0$, and $\Delta G^\circ > 0$. The values of ΔH° and ΔS° do not depend on the temperature. Which of the following is a correct conclusion about this process?
(A.) It is non-spontaneous at all T . (B.) It is spontaneous at high T .
(C.) It is spontaneous at low T . (D.) It is spontaneous at all T .
(E.) None of these conclusions is correct.
3. A mixture of 0.600 mol of bromine and 1.600 mol of iodine is placed into a rigid 1.000-L container at 350°C. $\text{Br}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{IBr}(g)$
When the mixture has come to equilibrium, the concentration of iodine monobromide is 1.190 M. What is the equilibrium constant for this reaction at 350°C?
(A.) 3.55×10^{-3} (B.) 1.24 (C.) 1.47 (D.) 282 (E.) 325
4. What is the molecular shape of SCl_3F as predicted by the VSEPR theory?
(A.) linear (B.) bent (C.) T-shaped (D.) see-saw (E.) trigonal pyramidal
5. According to the molecular orbital (MO) treatment of the NO molecule, what are the bond order and the number of unpaired electrons, respectively?
(A.) 2, 2 (B.) 3, 3 (C.) 1, 1 (D.) 1.5, 2 (E.) 2.5, 1
6. Most of the alkali metal salts are soluble in water while many alkaline earth salts have very low solubilities. Why is this so?
(A.) The alkali metal cations are smaller than the alkaline earth cations and are more easily hydrated.
(B.) The alkali metals have lower ionization energies than alkaline earth elements.
(C.) The alkaline earth metals have greater heats of atomization than the alkali metals.
(D.) The alkaline earth salts have much greater lattice energies than the alkali metal salts.
(E.) Alkaline earth cations have very low heats of hydration.

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7. When the adhesive forces between a liquid and the walls of a capillary tube are greater than the cohesive forces within the liquid
- (A.) the liquid level in a capillary tube will rise above the surrounding liquid and the surface in the capillary tube will have a convex meniscus.
- (B.) the liquid level in a capillary tube will drop below the surrounding liquid and the surface in the capillary tube will have a convex meniscus.
- (C.) the liquid level in a capillary tube will rise above the surrounding liquid and the surface in the capillary tube will have a concave meniscus.
- (D.) the liquid level in a capillary tube will drop below the surrounding liquid and the surface in the capillary tube will have a concave meniscus.
- (E.) None of these choices is correct.
8. Which of the following is a correct set of quantum numbers for an electron in a $3d$ orbital?
- (A.) $n = 3, l = 0, m_l = -1$ (B.) $n = 3, l = 1, m_l = +3$ (C.) $n = 3, l = 2, m_l = 3$
- (D.) $n = 3, l = 3, m_l = +2$ (E.) $n = 3, l = 2, m_l = -2$
9. Phosphoric acid, H_3PO_4 , is a triprotic acid, for which $K_{a1} = 7.2 \times 10^{-3}$, $K_{a2} = 6.3 \times 10^{-8}$ and $K_{a3} = 4.2 \times 10^{-13}$. What is the value of K_b for the hydrogen phosphate anion, HPO_4^{2-} ?
- (A.) 6.3×10^{-8} (B.) 4.2×10^{-13} (C.) 1.4×10^{-12} (D.) 1.6×10^{-7}
- (E.) 2.4×10^{-2}
10. Which of the following has the highest buffer capacity?
- (A.) $0.10\text{ M H}_2\text{PO}_4^- / 0.10\text{ M HPO}_4^{2-}$ (B.) $0.10\text{ M H}_2\text{PO}_4^- / 0.50\text{ M HPO}_4^{2-}$
- (C.) $0.50\text{ M H}_2\text{PO}_4^- / 0.50\text{ M HPO}_4^{2-}$ (D.) $0.50\text{ M H}_2\text{PO}_4^- / 0.10\text{ M HPO}_4^{2-}$
- (E.) They all have the same buffer capacity.
11. Consider the following redox equation
- $$\text{Mn}(\text{OH})_2(s) + \text{MnO}_4^-(aq) \rightarrow \text{MnO}_4^{2-}(aq) \text{ (basic solution)}$$
- When the equation is balanced with smallest whole number coefficients, what is the coefficient for $\text{OH}^-(aq)$ and on which side of the equation is $\text{OH}^-(aq)$ present?
- (A.) 6, reactant side (B.) 6, product side (C.) 4, reactant side
- (D.) 4, product side (E.) None of these choices is correct.

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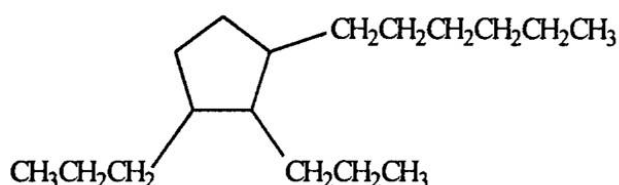
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12. How many unpaired electrons are there in the Fe^{3+} ion?
(A.) 5 (B.) 4 (C.) 3 (D.) 2 (E.) None of these choices is correct.
13. When the reaction $\text{A} \rightarrow \text{B} + \text{C}$ is studied, a plot $1/[\text{A}]_t$ vs. time gives a straight line with a positive slope. What is the order of the reaction?
(A.) third (B.) first (C.) zero (D.) second
(E.) More information is needed to determine the order.

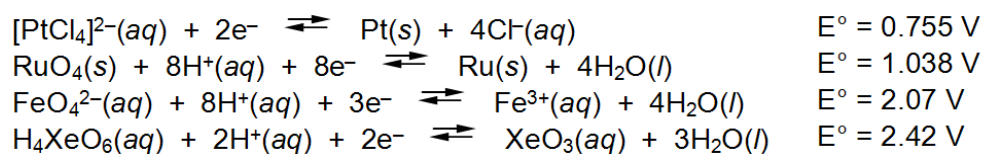
14. Select the correct name for the following compound.



- (A.) *ortho*-dipropylcyclopentylhexane (B.) 2,3-dipropylcyclopentylhexane
(C.) 2-hexyl-1,5-dipropylcyclopentane (D.) 1-hexyl-2,3-dipropylcyclopentane
(E.) 1,2-dipropyl-3-hexylcyclopentane
15. In a blast furnace, elemental iron is produced from a mixture of coke (C), iron ore (Fe_3O_4) and other reactants. An important reaction sequence is:

$$2\text{C}(s) + \text{O}_2(g) \rightarrow 2\text{CO}(g)$$

$$\text{Fe}_3\text{O}_4(s) + 4\text{CO}(g) \rightarrow 3\text{Fe}(l) + 4\text{CO}_2(g)$$
 How many moles of iron can be formed in this sequence when 1.00 mol of carbon, as coke, is consumed?
 (A.) 6.00 mol Fe (B.) 3.00 mol Fe (C.) 1.33 mol Fe (D.) 1.25 mol Fe
 (E.) 0.750 mol Fe
16. Examine the following half-reactions and select the strongest oxidizing agent among the substances.



- (A.) $[\text{PtCl}_4]^{2-}(aq)$ (B.) $\text{RuO}_4(s)$ (C.) $\text{HFeO}_4^-(aq)$ (D.) $\text{H}_4\text{XeO}_6(aq)$
(E.) $\text{Cl}^-(aq)$

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17. Bromine will form compounds with each of the other elements in Period 4 of the periodic table. How does the type of bonding in the compounds change as one moves from potassium bromide to selenium bromide?
(A.) polar covalent to non-polar covalent (B.) polar covalent to ionic
(C.) ionic to polar covalent (D.) coordinate covalent to polar covalent
(E.) None of these choices is correct.
18. Methane has a Henry's Law constant (k) of $9.88 \times 10^2 \text{ mol}/(\text{L}\cdot\text{atm})$ when dissolved in benzene at 25°C . How many grams of CH_4 will dissolve in 3.00 L of benzene if the partial pressure of CH_4 is 1.48 atm?
(A.) 0.0667 g (B.) 0.146 g (C.) 2.34 g (D.) 4.83 g (E.) 7.02 g
19. Carbon monoxide and chlorine combine in an equilibrium reaction to produce the highly toxic product, phosgene (COCl_2).
 $\text{CO}(g) + \text{Cl}_2(g) \rightleftharpoons \text{COCl}_2(g)$
If the equilibrium constant for this reaction is $K_c = 248$, predict, if possible, what will happen when the reactants and product are combined with the concentrations shown.
 $[\text{CO}] = [\text{Cl}_2] = 0.0200 \text{ M}$; $[\text{COCl}_2] = 0.0992 \text{ M}$
(A.) The reaction will proceed to the right. (B.) The reaction will proceed to the left.
(C.) The container volume needs to be specified before a prediction can be made.
(D.) The reaction is at equilibrium, and no change in concentrations will occur.
(E.) The temperature needs to be specified before a prediction can be made.
20. Lithium forms compounds which are used in dry cells and storage batteries and in high-temperature lubricants. It has two naturally occurring isotopes, ${}^6\text{Li}$ (isotopic mass = 6.015121 amu) and ${}^7\text{Li}$ (isotopic mass = 7.016003 amu). Lithium has an atomic mass of 6.9409 amu. What is the percent abundance of lithium-6?
(A.) 86.66% (B.) 92.50% (C.) 7.503% (D.) 6.080% (E.) 46.16%
21. Identify the principal organic product of the reaction between butane and chlorine.
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 + \text{Cl}_2 \xrightarrow{\text{light}}$
(A.) $\text{CH}_3\text{CH}_2\text{CHClCH}_3$ (B.) $\text{CH}_3\text{CHClCH}_3$ (C.) $\text{CH}_3\text{CH}_2\text{Cl}$ (D.) CH_3Cl
(E.) None of these choices is a major product of the reaction.

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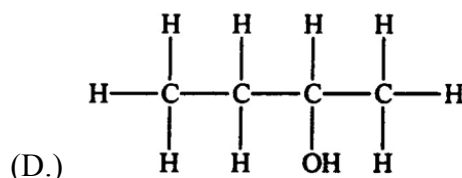
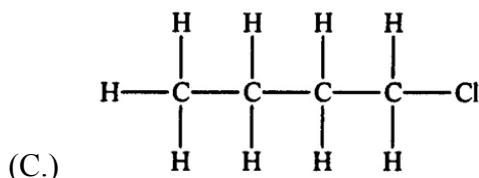
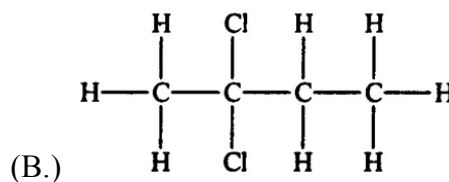
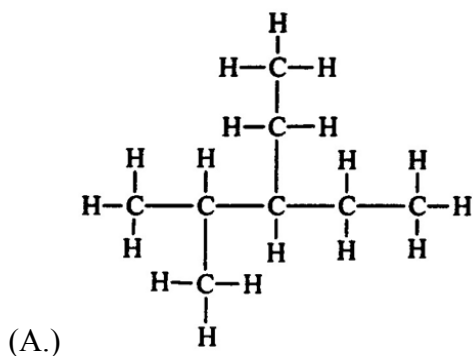
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22. For which one of the following reactions will ΔH be approximately (or exactly) equal to ΔE ?
- (A.) $\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g)$ (B.) $\text{H}_2(g) + \text{Br}_2(g) \rightarrow 2\text{HBr}(g)$
 (C.) $\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$ (D.) $2\text{H}(g) + \text{O}(g) \rightarrow \text{H}_2\text{O}(l)$
 (E.) $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l)$

23. Which one of the following classes of organic compound does not contain the carbonyl ($\text{C}=\text{O}$) group?
- (A.) aldehydes (B.) carboxylic acids (C.) alcohols (D.) esters
 (E.) None of these choices is correct.

24. Which compound, if any, will be optically active?



- (E.) None of these choices is optically active.

25. Calculate the ratio of the change in momentum per wall impact for $\text{Ar}(g)$ to that for $\text{He}(g)$ if the gases are at the same temperature and pressure. ($\text{He} = 4 \text{ g/mol}$, $\text{Ar} = 40 \text{ g/mol}$)
- (A) 10.0 (B) 0.01 (C) 0.316 (D) 0.10
 (E) None of these choices is correct.

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< II > 計算題 (共 5 題，佔 50 分，每題 10 分)

- (1) What is the $[H^+]$ of a 0.100M solution of NH_4CN .
(K_a of NH_4^+ is 5.6×10^{-10} , K_b of CN^- is 1.6×10^{-5} and K_w of H_2O is 1.0×10^{-14})
- (2) In the presence of aqueous cyanide, cadmium(II) forms the complex ion $Cd(CN)_4^{2-}$. Determine the molar concentration of free (uncomplexed) cadmium(II) ion in solution when 0.20 mole of $Cd(NO_3)_2$ is dissolved in a liter of 2.0 M sodium cyanide (NaCN).
(The formation constant (K_f) for the complex ion $Cd(CN)_4^{2-}$ is 7.1×10^{16})
- (3) In a titration of HNO_3 , you add a few drops of phenolphthalein indicator to 50.00 mL of acid in a flask. You quickly add 20.00 mL of 0.0502 M NaOH but overshoot the end point, and the solution turns deep pink. Instead of starting over, you add 30.00 mL of the acid, and the solution turns colorless. Then, it takes 3.22 mL of the NaOH to reach the end point. What is the concentration of the HNO_3 solution?
- (4) Sulfonation of benzene has the following mechanism:
- (I) $2 H_2SO_4 \rightarrow H_3O^+ + HSO_4^- + SO_3$ [fast]
(II) $SO_3 + C_6H_6 \rightarrow H(C_6H_5^+)SO_3^-$ [slow]
(III) $H(C_6H_5^+)SO_3^- + HSO_4^- \rightarrow C_6H_5SO_3^- + H_2SO_4$ [fast]
(IV) $C_6H_5SO_3^- + H_3O^+ \rightarrow C_6H_5SO_3H + H_2O$ [fast]
(a) Write an overall equation for the reaction (3%)
(b) Write the overall rate law for the initial rate of the reaction. (7%)
- (5) Use the following information to find ΔH_f° of methanol $[CH_3OH(l)]$:
- $$CH_3OH(l) + \frac{3}{2} O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)} \quad \Delta H_{rxn}^\circ = -638.5 \text{ kJ}$$
- $$\Delta H_f^\circ \text{ of } CO_{2(g)} = -393.5 \text{ kJ/mol} \quad \& \quad \Delta H_f^\circ \text{ of } H_2O_{(g)} = -241.8 \text{ kJ/mol}$$