國立高雄大學 109 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：化學工程及材料工程學系

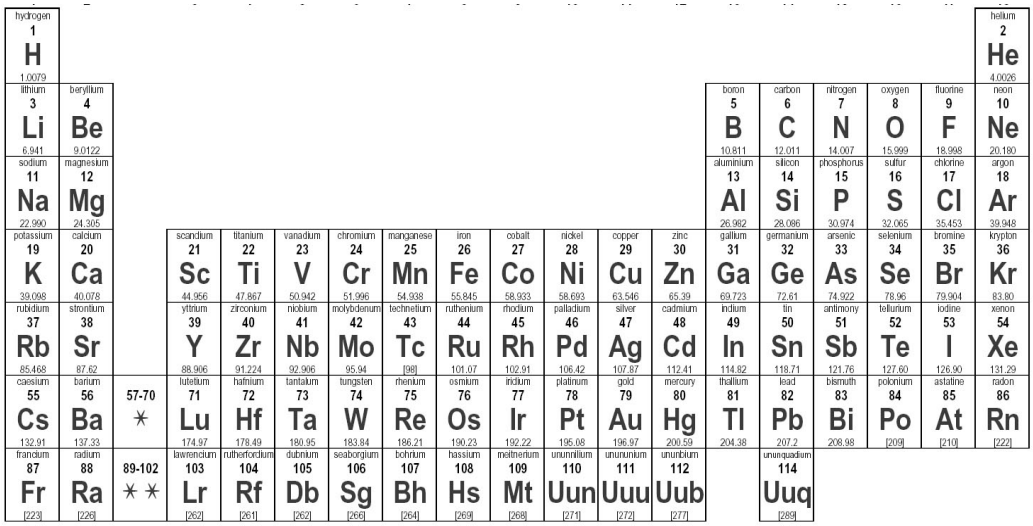
(無組別)

是否使用計算機：是

本科原始成績：100 分

參考資料

一、元素週期表



二、理想氣體常數、亞佛加厥常數

R = 8.314 J/mol·K = 0.0821 L·atm/K·mol; Avogadro's number = 6.02×10^{23}

< I >單一選擇題(共 20 題，佔 60 分，每題 3 分，答錯不倒扣)

1. The element lithium (Li) exists as two stable isotopes, ^{6}Li (isotopic mass = 6.200 amu) and ^{7}Li (isotopic mass = 7.200 amu). Lithium has an atomic mass of 7.125 amu. What is the percent abundance of ^{7}Li ?
   (A) 7.5 %　(B) 22.3%　(C) 90.2%　(D) 92.5%　(E) none of these
2. A chemical engineer dilutes a stock solution of hydrochloric acid (HCl) by adding 25.0 m^3 of 7.50 M acid to enough water to make 500 m^3. What is the mass (in g) of HCl per liter of the diluted solution? (M_w(HCl) = 36.46 g/mol)
   (A) 13.7　(B) 12.1　(C) 0.567　(D) 0.0136　(E) none of these
3. A rigid plastic container holds 45.5 g of methane (CH_4) at a pressure of 820 torr. What is the pressure (torr) if 3.5 g of methane is removed at constant temperature?
   (A) 723　(B) 757　(C) 808　(D) 794　(E) none of these
4. Which of the following statements is true?
   (A) The number of neutrons is the same for all neutral atoms of an element.

(B) Alkali metals form ions with a 2+ charge when they react with nonmetals.
(C) The molecule SO_2 has two resonance structures.
(D) The total energy of the universe decreases, while the entropy decreases.
(E) none of these

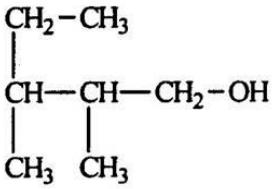
5. In a hydrogenation reaction, ethene (C_2H_4) and H_2 from ethane (C_2H_6). If 137 kJ is given off per mole of C_2H_4 reacting, how much heat (kJ) is released when 12.6 g of C_2H_6 forms? ($Mw(C_2H_6)$ = 30.07 g/mol)
(A) 57.4 (B) 28.7 (C) 14.4 (D) 0 (E) none of these

6. Balance the following redox equation using the smallest integers possible and select the correct coefficient for the HI.
$K_2Cr_2O_{7(aq)} + HI_{(aq)} \rightarrow KI_{(aq)} + CrI_{3(aq)} + I_{2(s)} + H_2O_{(l)}$
(A) 1 (B) 2 (C) 4 (D) 7 (E) none of these

7. Which of the following statements is incorrect?
(A) NF_3 is a polar molecule.
(B) The hybridization of the central atom is sp^3 in ICl_4^- ?
(C) According to the molecular orbital model, the bond order of P_2 molecule is three.
(D) A material is made from Al, Ga, and As. The mole fraction of each element is 0.25, 0.26, and 0.49, respectively. This material would be an p-type semiconductor.
(E) none of these

8. Which of the following electron configurations belongs to an atom that is most likely to be involved in a covalent bond?
(A) $1s^2 2s^2 2p^6 3s^2$ (B) $1s^2 2s^2 2p^6 3s^2 3p^3$ (C) $1s^2 2s^2 2p^6$ (D) $1s^2 2s^2 2p^6 3s^2 3p^6$ (E) none of these

9. Select the correct name for the following compound.



(A) 3-ethyl-2,3-dimethyl-1-propanol (B) 2,3,4-trimethyl-1-butanol (C) 2,3-dimethyl-1-pentanol
(D) 3,4-dimethyl-5-pentanol (E) none of these

10. A certain gas expands in volume from 1.0 L to 2.0 L at constant temperature. Calculate the work done by the gas if it expands against a vacuum. (1 L·atm = 101.3 J).
(A) +202.6 J (B) –101.3 J (C) +101.3 J (D) 0 J (E) none of these

11. Which of the following statements about voltaic (galvanic) and electrolytic cells is correct?
(A) The anode will definitely gain weight in a voltaic cell.

(B) Oxidation occurs at the cathode of both cells.
(C) The free energy change, ΔG, is negative for the voltaic cell.
(D) The electrons in the external wire flow from cathode to anode in an electrolytic cell.
(E) none of these.

12. Calculate $E°_{cell}$ and indicate whether the overall reaction shown is spontaneous or nonspontaneous.
$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$ $E^o = 1.229$ V
$Al^{3+}_{(aq)} + 3e^- \rightarrow Al_{(s)}$ $E^o = -1.662$ V
Overall reaction:
$4Al_{(s)} + 3O_{2(g)} + 12H^+_{(aq)} \rightarrow 4Al^{3+}_{(aq)} + 6H_2O_{(l)}$
(A) $E°_{cell} = -2.891$ V, nonspontaneous (B) $E°_{cell} = -2.891$ V, spontaneous
(C) $E°_{cell} = 2.891$ V, nonspontaneous (D) $E°_{cell} = 2.891$ V, spontaneous
(E) none of these

13. Formic acid (HCOOH) has a $K_a = 1.8 \times 10^{-4}$. What is the $[H_3O^+]$ in a solution that is initially 0.10 *M* formic acid?
(A) 4.2×10^{-3} *M* (B) 8.4×10^{-3} *M* (C) 1.8×10^{-4} *M* (D) 1.8×10^{-5} *M* (E) none of these

14. When a weak acid is titrated with a strong base, the pH at the equivalence point?
(A) is less than 7.0 (B) is equal to 7.0 (C) is greater than 7.0
(D) is equal to the pK_a of the acid (E) none of these

15. What elements are alloyed to make stainless steel?
(A) Fe and C (B) Fe and Mn (C) Fe and Zn (D) Fe, V and Zn (E) Fe, Cr and Ni

16. 30.0 mL of a 0.100 mol/L solution of a metal ion M^{2+} is mixed with 30.0 mL of a 0.100 mol/L solution of a ligand L. A reaction occurs in which the product is ML_4^{2+}. Approximately, what is the maximum concentration of ML_4^{2+}, in mol/L, which could result from this reaction?
(A) 0.0250 (B) 0.250 (C) 0.180 (D) 0.0125 (E) none of these

17. Which one of the following statements about solid Cu (face-centered cubic unit cell) is incorrect?
(A) The solid has a cubic closest-packed structure.
(B) The number of atoms surrounding each Cu atom is 12.
(C) There are two atoms per unit cell.
(D) The length of a face diagonal is four times the Cu radius.
(E) none of these.

18. What is the molecular shape of BrF_5 as predicted by the VSEPR theory?
(A) Trigonal bipyramidal (B) Square planar (C) T shaped (D) Seesaw (E) none of these

19. The rate expression for a particular reaction is rate = $k[A]^2[B]$. If the initial concentration of B is increased from 0.1 *M* to 0.4 *M*, the initial rate will increase by which of the following factors?

(A) 2 (B) 4 (C) 8 (D) 16 (E) none of these

20. For the reaction $FeCl_{2(aq)} + O_{2(g)} \rightarrow Fe_2O_{3(s)} + Cl_{2(g)}$ (**unbalanced**), what volume (mL) of a 1.25 M solution of $FeCl_2$ is required to react completely with 4.32×10^{22} molecules of O_2?
(A) 76.5 (B) 38.3 (C) 125.2 (D) 57.4 (E) none of these

< II >計算題 (共 4 題，佔 40 分，每題 10 分)

(1) For the process $Br_{2(l)} \rightarrow Br_{2(g)}$, $\Delta H° = 31.0$ kJ/mol and $\Delta S° = 93.0$ J/K·mol. What is the normal boiling point (K) of liquid Br_2?

(2) Find the solubility of solid CaF_2 ($K_{sp} = 4.0 \times 10^{-11}$) in a 0.025 M NaF solution.

(3) Methane (CH_4) reacts with chlorine gas (Cl_2) form chloromethane (CH_3Cl), as the following equation; $CH_{4(g)} + Cl_{2(g)} \rightarrow CH_3Cl_{(g)} + HCl_{(g)}$

When 20.5 g of methane and 45.0 g of chlorine gas undergo a reaction that has a 65% yield. What mass of the chloromethane (CH_3Cl) forms? ($M_w(CH_4) = 16.04$ g/mol, $M_w(Cl_2) = 70.90$ g/mol, $M_w(CH_3Cl) = 50.48$ g/mol)

(4) Given the following reactions of nitrogen oxides and their standard enthalpy changes,

(1) $NO_{(g)} + NO_{2(g)} \rightarrow N_2O_{3(g)}$ $\Delta H^o_{rxn} = -39.8$ kJ

(2) $NO_{(g)} + NO_{2(g)} + O_{2(g)} \rightarrow N_2O_{5(g)}$ $\Delta H^o_{rxn} = -112.5$ kJ

(3) $2NO_{2(g)} \rightarrow N_2O_{4(g)}$ $\Delta H^o_{rxn} = -57.2$ kJ

(4) $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ $\Delta H^o_{rxn} = -114.2$ kJ

(5) $N_2O_{5(s)} \rightarrow N_2O_{5(g)}$ $\Delta H^o_{subl} = 54.1$ kJ

Calculate the heat of reaction for

$N_2O_{3(g)} + N_2O_{5(s)} \rightarrow 2N_2O_{4(g)}$