

國立高雄大學 109 學年度研究所碩士班招生考試試題

系所：化學工程及材料工程學系

科目：普通化學

(無組別)

是否使用計算機：是

考試時間：100 分鐘

本科原始成績：100 分

參考資料

一、元素週期表

hydrogen 1 H 1.0079																	helium 2 He 4.0026				
lithium 3 Li 6.941	beryllium 4 Be 9.0122															boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305															aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80				
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29				
cesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 ★		lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]		
francium 87 Fr [223]	radium 88 Ra [226]	89-102 ★★★		lawrencium 103 Lr [260]	rutherfordium 104 Rf [261]	dundium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [265]	meitnerium 109 Mt [268]	unnilium 110 Uun [271]	ununium 111 Uuu [272]	unbibium 112 Uub [277]	ununquadium 114 Uuq [289]							

二、理想氣體常數、亞佛加厥常數

$$R = 8.314 \text{ J/mol} \cdot \text{K} = 0.0821 \text{ L} \cdot \text{atm/K} \cdot \text{mol}; \text{ Avogadro's number} = 6.02 \times 10^{23}$$

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

- The element lithium (Li) exists as two stable isotopes, ${}^6\text{Li}$ (isotopic mass = 6.200 amu) and ${}^7\text{Li}$ (isotopic mass = 7.200 amu). Lithium has an atomic mass of 7.125 amu. What is the percent abundance of ${}^7\text{Li}$?
(A) 7.5 % (B) 22.3% (C) 90.2% (D) 92.5% (E) none of these
- A chemical engineer dilutes a stock solution of hydrochloric acid (HCl) by adding 25.0 m³ of 7.50 M acid to enough water to make 500 m³. What is the mass (in g) of HCl per liter of the diluted solution? ($M_w(\text{HCl}) = 36.46 \text{ g/mol}$)
(A) 13.7 (B) 12.1 (C) 0.567 (D) 0.0136 (E) none of these
- 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
- Which of the following statements is true?
(A) The number of neutrons is the same for all neutral atoms of an element.

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(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.

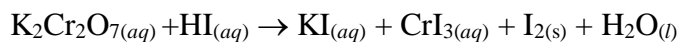
(E) none of these

5. In a hydrogenation reaction, ethene (C_2H_4) and H_2 form 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?

($M_w(\text{C}_2\text{H}_6) = 30.07 \text{ g/mol}$)

(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.



(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.

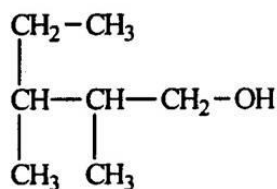
(D) A material is made from Al, Ga, and As. The mole fraction of each element is 0.25, 0.26, and 0.49, respectively. This material would be an p-type semiconductor.

(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. ($1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$).

(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.

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- (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.
 $\text{O}_{2(g)} + 4\text{H}^+_{(aq)} + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}_{(l)} \quad E^\circ = 1.229 \text{ V}$
 $\text{Al}^{3+}_{(aq)} + 3\text{e}^- \rightarrow \text{Al}_{(s)} \quad E^\circ = -1.662 \text{ V}$
 Overall reaction:
 $4\text{Al}_{(s)} + 3\text{O}_{2(g)} + 12\text{H}^+_{(aq)} \rightarrow 4\text{Al}^{3+}_{(aq)} + 6\text{H}_2\text{O}_{(l)}$
 (A) $E^\circ_{\text{cell}} = -2.891 \text{ V}$, nonspontaneous (B) $E^\circ_{\text{cell}} = -2.891 \text{ V}$, spontaneous
 (C) $E^\circ_{\text{cell}} = 2.891 \text{ V}$, nonspontaneous (D) $E^\circ_{\text{cell}} = 2.891 \text{ V}$, spontaneous
 (E) none of these
13. Formic acid (HCOOH) has a $K_a = 1.8 \times 10^{-4}$. What is the $[\text{H}_3\text{O}^+]$ in a solution that is initially 0.10 M formic acid?
 (A) $4.2 \times 10^{-3} \text{ M}$ (B) $8.4 \times 10^{-3} \text{ M}$ (C) $1.8 \times 10^{-4} \text{ M}$ (D) $1.8 \times 10^{-5} \text{ M}$ (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 $\text{p}K_a$ 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 $\text{rate} = k[\text{A}]^2[\text{B}]$. 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?

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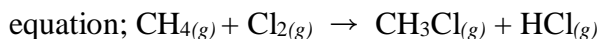
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(A) 2 (B) 4 (C) 8 (D) 16 (E) none of these

20. For the reaction $\text{FeCl}_{2(aq)} + \text{O}_{2(g)} \rightarrow \text{Fe}_2\text{O}_{3(s)} + \text{Cl}_{2(g)}$ (**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

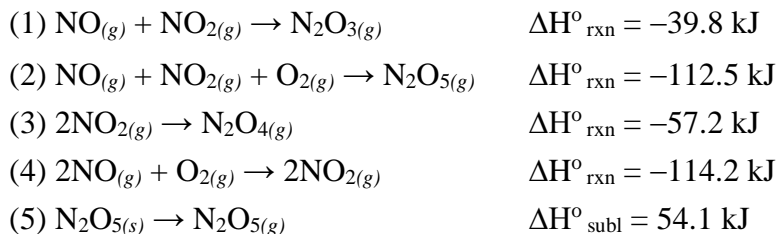
< II > 計算題 (共 4 題，佔 40 分，每題 10 分)

- (1) For the process $\text{Br}_{2(l)} \rightarrow \text{Br}_{2(g)}$, $\Delta H^\circ = 31.0 \text{ kJ/mol}$ and $\Delta S^\circ = 93.0 \text{ J/K}\cdot\text{mol}$. 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



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? ($M_w(\text{CH}_4) = 16.04 \text{ g/mol}$, $M_w(\text{Cl}_2) = 70.90 \text{ g/mol}$, $M_w(\text{CH}_3\text{Cl}) = 50.48 \text{ g/mol}$)

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



Calculate the heat of reaction for

