國立中正大學 106 學年度碩士班招生考試試題

系所別：化學暨生物化學系　　科目：一般化學

- 單一選擇 1～25題，每題 3分，共計 75分，答錯不倒扣；簡答題 26～30題，每題 5分，共計 25分。
- 請在答案卷上作答。
- 常數　Avogadro's constant $N = 6.022 \times 10^{23}\ \text{mol}^{-1}$　　Planck's constant $h = 6.626 \times 10^{-34}\ \text{J·s}$
  Gas constant $R = 0.8206\ \text{L·atm·K}^{-1}\text{·mol}^{-1} = 8.3145\ \text{J·K}^{-1}\text{·mol}^{-1}$　　Faraday constant $F = 96500\ \text{C·mol}^{-1}$
  Speed of light $c = 3 \times 10^{8}\ \text{m·s}^{-1}$

Periodic Table of Elements

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 1.008																		He 4.003
Li 6.941	Be 9.012												B 10.811	C 12.011	N 14.007	O 15.999	F 18.998	Ne 20.180
Na 22.990	Mg 24.305												Al 26.982	Si 28.086	P 30.974	S 32.065	Cl 35.453	Ar 39.948
K 39.098	Ca 40.078		Sc 44.956	Ti 47.867	V 50.942	Cr 51.996	Mn 54.938	Fe 55.845	Co 58.933	Ni 58.693	Cu 63.546	Zn 65.39	Ga 69.723	Ge 72.61	As 74.922	Se 78.96	Br 79.904	Kr 83.80
Rb 85.468	Sr 87.62		Y 88.906	Zr 91.224	Nb 92.906	Mo 95.94	Tc [98]	Ru 101.07	Rh 102.91	Pd 106.42	Ag 107.87	Cd 112.41	In 114.82	Sn 118.71	Sb 121.76	Te 127.60	I 126.90	Xe 131.29
Cs 132.91	Ba 137.33	57-70 *	Lu 174.97	Hf 178.49	Ta 180.95	W 183.84	Re 186.21	Os 190.23	Ir 192.22	Pt 195.08	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98	Po [209]	At [210]	Rn [222]
Fr [223]	Ra [226]	89-102 * *	Lr [262]	Rf [261]	Db [262]	Sg [266]	Bh [264]	Hs [269]	Mt [268]	Uun [271]	Uuu [272]	Uub [277]		Uuq [289]				

*Lanthanide series	La 138.91	Ce 140.12	Pr 140.91	Nd 144.24	Pm [145]	Sm 150.36	Eu 151.96	Gd 157.25	Tb 158.93	Dy 162.50	Ho 164.93	Er 167.26	Tm 168.93	Yb 173.04
**Actinide series	Ac [227]	Th 232.04	Pa 231.04	U 238.03	Np [237]	Pu [244]	Am [243]	Cm [247]	Bk [247]	Cf [251]	Es [252]	Fm [257]	Md [258]	No [259]

1. The valve between a 3.60-L tank containing $O_2(g)$ at 7.56 atm and a 3.40-L tank containing Ne(g) at 5.92 atm is opened. Calculate the ratio of partial pressures (O_2 : Ne) in the container.
   A) 1.06　　B) 1.28　　C) 1.35　　D) 0.74　　E) 0.56

2. At 200 K, the molecules or atoms of an unknown gas, X, have an average velocity equal to that of Ar atoms at 400 K. What is X? (Assume ideal behavior.)
   A) He　　B) CO　　C) HF　　D) HBr　　E) F_2

3. At a given temperature, the equilibrium constant K for the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is 3.0×10^9. If 2.60 mole of SO_2 and 3.90 mole of O_2 are placed in a 1.78-L container and allowed to react to equilibrium at this temperature, what is the concentration of SO_3 at equilibrium?
   A) 0.73 M　　B) 1.46 M　　C) 2.19 M　　D) 2.92 M　　E) 3.65 M

4. For carbonic acid (H_2CO_3), $K_{a1} = 4.30 \times 10^{-7}$ and $K_{a2} = 5.62 \times 10^{-11}$. Calculate the pH of a 0.50 M solution of Na_2CO_3.
   A) 2.03　　B) 3.33　　C) 8.31　　D) 10.67　　E) 11.97

5. You have solutions of 0.200 M HNO_2 and 0.200 M KNO_2 (K_a for $HNO_2 = 4.00 \times 10^{-4}$). A buffer of pH 3.00 is needed. What volumes of HNO_2 and KNO_2 are required to make 1 L of buffered solution?
   A) 500 mL of each　　B) 286 mL HNO_2; 714 mL KNO_2　　C) 413 mL HNO_2; 587 mL KNO_2
   D) 714 mL HNO_2; 286 mL KNO_2　　E) 587 mL HNO_2; 413 mL KNO_2

6. The overall K_f for the complex ion $Ag(NH_3)_2^+$ is 1.7×10^7. K_{sp} for AgI is 1.5×10^{-16}. What is the molar solubility of AgI in a solution that is 2.0 M in NH_3?
   A) 1.3×10^{-3}　　B) 1.0×10^{-4}　　C) 8.4×10^{-5}　　D) 1.5×10^{-9}　　E) 5.8×10^{-12}

7. For the combustion of ethyl alcohol: $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ $\Delta H = -1.37 \times 10^3$ kJ, which of the following statements is(are) true?

I. The reaction is exothermic.
II. The enthalpy change would be different if gaseous water were produced.
III. The reaction is not an oxidation–reduction one.
IV. The products of the reaction occupy a larger volume than the reactants.

A) I, II　B) III, IV　C) I, II, III　D) II, III, IV　E) I, II, III, IV

8. For the reactions $AgI(s) + (1/2)Br_2(g) \rightarrow AgBr(s) + (1/2)I_2(s)$, $\Delta H° = -54.0$ kJ
$\Delta H°_f$ for $AgBr(s) = -100.4$ kJ/mol
$\Delta H°_f$ for $Br_2(g) = +30.9$ kJ/mol
The value of $\Delta H°_f$ for $AgI(s)$ is

A) +77.3 kJ/mol　B) +61.8 kJ/mol　C) –61.8 kJ/mol　D) –77.3 kJ/mol　E) –123.5 kJ/mol

9. For the reaction A + B → C + D, $\Delta H° = +40$ kJ and $\Delta S° = +50$ J/K. Therefore, the reaction under standard conditions is

A) spontaneous at temperatures less than 10 K.
B) spontaneous at temperatures greater than 800 K
C) spontaneous only at temperatures between 10 K and 800 K
D) spontaneous at all temperatures.
E) nonspontaneous at all temperatures.

10. When the equation for the following reaction in basic solution is balanced, what is the sum of the coefficients?
$MnO_4^-(aq) + CN^-(aq) \rightarrow MnO_2(s) + CNO^-(aq)$

A) 20　B) 13　C) 11　D) 10　E) 8

11. The reduction potentials for Au^{3+} and Ni^{2+} are as follows: $Au^{3+} + 3e^- \rightarrow Au$ $E° = +1.50$ V
$Ni^{2+} + 2e^- \rightarrow Ni$ $E° = -0.23$ V
Calculate $\Delta G°$ (at 25°C) for the reaction $2Au^{3+} + 3Ni \rightarrow 3Ni^{2+} + 2Au$

A) +500 kJ　B) +1,000 kJ　C) –2,140 kJ　D) –1,000 kJ　E) –500 kJ

12. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be 3.31×10^{-3} pm.
Which element is this?

A) He　B) F　C) P　D) Ca　E) Br

13. The ionization energy for a hydrogen atom is 1.31×10^6 J/mol. What is the ionization energy for Li^{2+}?

A) 1.46×10^5 J/mol　B) 4.37×10^5 J/mol　C) 1.31×10^6 J/mol　D) 3.93×10^6 J/mol　E) 1.18×10^7 J/mol

14. Consider the following orderings.

I. Al < Si < P < Cl
II. Be < Mg < Ca < Sr
III. I < Br < Cl < F
IV. $Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}$

Which of these give(s) a correct trend in ionization energy?

A) III only　B) I and II　C) I and IV　D) I, III and IV　E) all of them

15. Which atomic species, in its ground state, has six unpaired electrons?

A) O　B) Fe　C) Cr　D) Cs　E) Dy

16. Which of the following series is isoelectronic?

A) S^{2-}, Cl^-, K^+, Ca^{2+}　B) B, C, N, O　C) F^-, Cl^-, K^+, Rb^+　D) Na, K, Rb, Cs　E) Sn, As, S, F

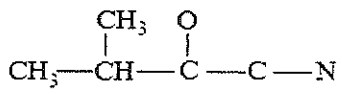
17. Using the following bond energies:

Bond	C≡C	C–H	O=O	C=O	O–H
Bond Energy (kJ/mol)	839	413	495	799	467

estimate the heat of combustion for 1 mol of acetylene: $C_2H_2(g) + 5/2\ O_2(g) \longrightarrow 2\ CO_2(g) + H_2O(g)$

A) –1228 kJ　B) –447 kJ　C) +365 kJ　D) +447 kJ　E) +1228 kJ

18. Complete the Lewis structure for the following molecule.



How many of the atoms are sp^2 hybridized?

A) 1　B) 2　C) 3　D) 4　E) 5

19. A first-order reaction is 50% complete at the end of 12 min. What is the value of the rate constant? (ln2 = 0.693)

A) 0.65 min^{-1}　B) 0.33 min^{-1}　C) 0.083 min^{-1}　D) 0.058 min^{-1}　E) 0.042 min^{-1}

20. An X-ray diffraction experiment finds the metal X crystallizes in a face-centered cubic lattice and measures the edge of the unit cell as 409 pm. If the density of the metal X to be 10.5 g/cm^3, what is X most likely to be?

A) Ag　B) Cr　C) Pt　D) Al　E) Pb

21. A 5.96-g sample of a compound is dissolved in 222.0 g of benzene. The freezing point of this solution is 1.06°C below that of pure benzene. What is the molar mass of this compound? (*Note:* K_f for benzene = 5.12°C/*m*.)

A) 1,300 g/mol　B) 556 g/mol　C) 285 g/mol　D) 180 g/mol　E) 130 g/mol

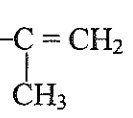
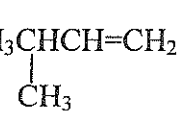
22. What is the expected osmotic pressure, in torr, of a 0.0100 *M* solution of NaCl in water at 25°C?

A) 372 torr　B) 186 torr　C) 93 torr　D) 15.6 torr　E) 0.245 torr

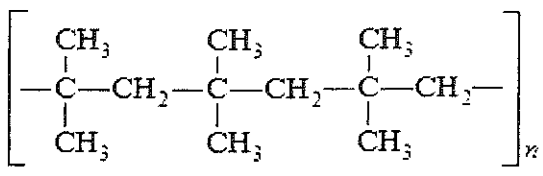
23. How many different possible trimethylbenzenes exist?

A) 2　B) 3　C) 4　D) 5　E) 6

24. When an organic species is treated with water and H_2SO_4, a tertiary alcohol is produced. Which of the following structures could represent this compound?

A) $CH_3CH=CHCH_3$　B) $CH_3CH_2CH=CH_2$　C)  　D) $CH_3CH_2CH_2CH_3$　E) 

25. Consider the polymer drawn below:



What monomer(s) is (are) needed to produce the above polymer?

A) $CH_2=CH_2$ and $CH_3CH=CH_2$　B) CO and $CH_2=CH_2$　C) $CH_3CH=CHCH_3$

D) $CH_2=CH—CH=CH_2$　E) $CH_2=C(CH_3)_2$

26. Consider the following sets of quantum numbers. Find the set(s) represent(s) impossible combinations and the incorrect quantum number(s).

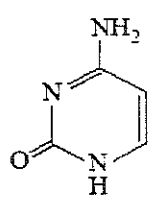
	n	*l*	m_l	m_s
Set A	1	1	0	+1/2
Set B	2	0	0	–1/2
Set C	2	1	–2	+1/2
Set D	3	1	–1	0
Set E	3	2	–1	–1/2
Set F	4	3	4	–1/2
Set G	5	4	2	+1/2
Set H	8	1	0	–1/2

27. Arrange the following compounds in the order of molar solubility (moles per liter) in water at 25°C.
A) $CaSO_4$ ($K_{sp} = 6.1 \times 10^{-5}$)　B) $PbSO_4$ ($K_{sp} = 1.3 \times 10^{-8}$)　C) Ag_3PO_4 ($K_{sp} = 1.8 \times 10^{-18}$)
D) $Sn(OH)_2$ ($K_{sp} = 3.0 \times 10^{-27}$)　E) $Al(OH)_3$ ($K_{sp} = 2.0 \times 10^{-32}$)

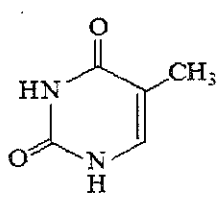
28. Draw the geometric and optical isomers of the complex ion $[Co(en)_2Cl_2]^+$. (en = ethylenediamine, $NH_2CH_2CH_2NH_2$).

29. Which of the following are polar molecules?
A) SF_2　B) KrF_2　C) BBr_3　D) PBr_3　E) ICl_3　F) XeO_4　G) SiF_4　H) SBr_6

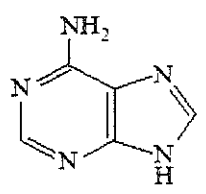
30. Deoxyribonucleic acid (DNA) has a double-helical structure with complementary bases on the two strands. Four nitrogen-containing organic bases existing in DNA are shown below. Which base is always bonded to thymine in DNA double helix? Draw the hydrogen bonding interactions between this complementary pair.



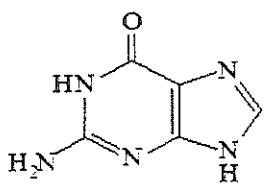
Cytosine (C)



Thymine(T)



Adenine (A)



Guanine (G)