類組：化學類　科目：綜合化學(1001)　　共 7 頁 第 1 頁

※請在答案卡內作答

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	2 He 4.003
3 Li 6.941	4 Be 9.012																10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 *La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 †Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (268)	110 Ds (271)	111 Rg (280)	112 Uub		114 Uuq		116 Uuh		118 Uuo

*Lanthanide series	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
†Actinide series	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

單選題（共 40 題，每題 2.5 分，滿分為 100 分）

1. In the ground state of a cobalt atom there are _____ unpaired electrons and the atom is _____.

(A) 3, paramagnetic (B) 5, paramagnetic (C) 2, diamagnetic

(D) 0, diamagnetic (E) 2, paramagnetic

2. Which one of the following is an amphoteric metal hydroxide?

(A) KOH (B) $Ba(OH)_2$ (C) $Pb(OH)_2$ (D) LiOH (E) $Mg(OH)_2$

3. Assuming the K_{sp} for $Mg(OH)_2$ is 1.8×10^{-11}, what is the pH of a saturated solution of $Mg(OH)_2$?

(A) 3.5 (B) 10.1 (C) 10.9 (D) 10.5 (E) 9.2

4. Assuming the K_{sp} for Ag_3PO_4 is 1.8×10^{-18}, Ag_3PO_4 would be <u>least soluble</u> at 25°C in which of the followings?

(A) 0.1 M $AgNO_3$ (B) 0.1 M HNO_3 (C) pure water (D) 0.1 M Na_3PO_4

(E) solubility in (A), (B), (C), or (D) is not different

5. The perchloric acid molecule contains:

(A) 13 lone pairs, 1 π bond, and 4 σ bonds. (B) 9 lone pairs, no π bonds, and 6 σ bonds.

(C) 8 lone pairs, 2 π bonds, and 7 σ bonds. (D) 2 lone pairs, 3 π bonds, and 4 σ bonds.

(E) 11 lone pairs, no π bonds, and 5 σ bonds.

6. What hybridization is predicted for sulfur in the HSO_3^- ion?

(A) sp (B) sp^2 (C) sp^3 (D) sp^3d (E) sp^3d^2

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7. Both ZnS and CaF_2 have a face-centered cubic unit cell where the S^{2-} and Ca^{2+} ions are closest packed in each structure. Which of the following is true?

(A) There are 4 tetrahedral holes empty in each structure.

(B) In both compounds, one-half of the tetrahedral holes are filled.

(C) In both compounds, all the tetrahedral holes are filled.

(D) In ZnS, one-half of the tetrahedral holes are filled by Zn^{2+} ions, whereas in CaF_2 all the tetrahedral holes are filled with F^- ions.

(E) There are 8 Zn^{2+} ions and 4 F^- ions in the unit cell.

8. Na_2S crystallizes with an antifluorite structure. Which statement is true about this structure?

(A) The coordination number of each S^{2-} center is 8.

(B) Each Na^+ ion is within a cubic arrangement of S^{2-} ions.

(C) The structure is based on a CaF_2 structure, with Na^+ ions in Na_2S occupying the same sites as Ca^{2+} ions in CaF_2.

(D) The S^{2-} ion is tetrahedrally coordinated.

(E) None is correct.

9. A possible mechanism for the reaction, $2A + B \rightarrow C + D$, is:

(1) $A + A \rightleftharpoons A_2$ fast, equilibrium

(2) $A_2 + A \rightarrow A_3$ slow

(3) $A_3 + B \rightarrow A + C + D$ fast

According to the mechanism, the rate law will be:

(A) Rate = $k[A]^2$ (B) Rate = $k[A][B]$ (C) Rate = $k[A]^2[B]$ (D) Rate = $k[A]$

(E) Rate = $k[A]^3$

10. Suppose the activation energy of a certain reaction is 250 kJ/mol. If the rate constant at T_1 = 300 K is k_1 and the rate constant at T_2 = 320 K is k_2, then the reaction is __ times faster at 320 K than at 300 K. (Hint: Solve for k_2/k_1.and Euler's number ***e*** approximately equal to 2.718)

(A) 3×10^{-29} (B) 0.067 (C) 15.0 (D) 525 (E) 3×10^{-28}

11. The half-reaction that occurs at the anode during the electrolysis of molten sodium bromide is:

(A) $2\,Br^- \rightarrow Br_2 + 2\,e^-$ (B) $Br_2 + 2\,e^- \rightarrow 2\,Br^-$ (C) $Na^+ + e^- \rightarrow Na$

(D) $Na \rightarrow Na^+ + e^-$ (E) $2\,H_2O + 2\,e^- \rightarrow 2\,OH^- + H_2$

12. Which one of the following substances can be melted without breaking chemical bonds?

(A) sodium sulfate (B) zinc chloride (C) sulfur dioxide (D) silicon dioxide

(E) diamond

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13. At 445°C, K_c for the following reaction is 0.020.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

A mixture of H_2, I_2, and HI in a vessel at 445°C has the following concentrations: [HI] = 2.0 M, [H_2] = 0.50 M and [I_2] = 0.10 M. Which one of the following statements concerning the reaction quotient, Q_c, is **TRUE** for the above system?

(A) $Q_c = K_c$; the system is at equilibrium.

(B) Q_c is less than K_c; more H_2 and I_2 will be produced.

(C) Q_c is less than K_c; more HI will be produced.

(D) Q_c is greater than K_c; more H_2 and I_2 will be produced.

(E) Q_c is greater than K_c; more HI will be produced.

14. Consider the complex ion $[Mn(OH_2)_6]^{2+}$ with 5 unpaired electrons. Which response includes all the following statements that are **true**, and no false statements?

I. It is diamagnetic.　II. It is a low spin complex.　III. The metal ion is a d^5 ion.

IV. The ligands are weak field ligands.　V. It is octahedral.

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

15. Which of the following complexes do you expect to be brightly colored?

(A) $Cs_2[TiCl_6]$　(B) [Zn(pic)Cl_2] (pic: picolinic acid)　(C) $[Mn(H_2O)_6]SO_4$

(D) $[Fe(H_2O)_4(SCN)_2]$　(E) None is correct.

16. Which of the following complexes do you expect to be kinetically inert?

(A) $[Co(NH_3)_4]^{2+}$　(B) $[Fe(CN)_6]^{4-}$　(C) $[Zn(CN)_4]^{2-}$　(D) $[Ti(H_2O)_6]^{3+}$　(E) None is correct.

17. Which of the following complexes shows color?

(A)$[Zn(H_2O)_6](SO_4)$　(B) $[Cu(H_2O)_6]Cl$　(C) $[Cr(H_2O)_6]Cl_3$　(D) $Cd(NO_3)_2$　(E) None is correct.

18. Magnetic measurements indicate that $[Co(OH_2)_6]^{2+}$ has 3 unpaired electrons. Therefore, the hybridization of the metal's orbitals in $[Co(OH_2)_6]^{2+}$ is:

(A) sp^3　(B) sp^2d　(C) dsp^2　(D) sp^3d^2　(E) d^2sp^3

19. Which one of the following statements is **FALSE**?

(A) In an octahedral crystal field, the d electrons on a metal ion occupy the e_g set of orbitals before they occupy the t_{2g} set of orbitals.

(B) Diamagnetic metal ions cannot have an odd number of electrons.

(C) Low spin complexes can be paramagnetic.

(D) In high spin octahedral complexes, Δ_{oct} is less than the electron pairing energy, and is relatively very small.

(E) Low-spin complexes contain strong field ligands.

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20. Which of the following complexes has the greatest thermodynamic stability (en = H_2N-CH_2CH_2-NH_2)? Note: assume a high-spin configuration for Mn in these complexes.

(A) $[Mn(NH_3)_6]^{2+}$　(B) $[Zn(NH_3)_6]^{2+}$　(C) $[Mn(en)_3]^{2+}$　(D) $[Zn(en)_3]^{2+}$　(E) None is correct.

21. Place the following in order of increasing acid strength.

H_2O　CH_3OH　C_6H_5OH　CH_3COOH

(A) $CH_3OH < C_6H_5OH < H_2O < CH_3COOH$

(B) $H_2O < CH_3OH < C_6H_5OH < CH_3COOH$

(C) $H_2O < C_6H_5OH < CH_3OH < CH_3COOH$

(D) $CH_3OH < H_2O < C_6H_5OH < CH_3COOH$

(E) $C_6H_5OH < CH_3OH < H_2O < CH_3COOH$

22. Which of the following statements is **TRUE**?

(A) A strong acid is composed of a proton and an anion that have a very strong attraction for one another.

(B) A weak base is composed of a cation and an anion with a very weak attraction between them.

(C) A strong acid has a strong conjugate base.

(D) The conjugate base of a very weak acid is stronger than the conjugate base of a strong acid.

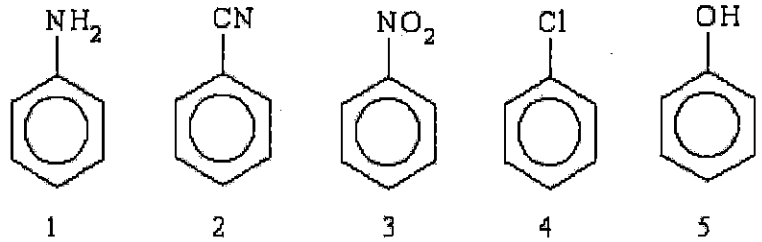
(E) None of the above statements are true.

23. Identify the missing particle in the following nuclear equation:

$$^{235}_{92}U \rightarrow {}^{90}_{38}Sr + ? + 2\,{}^{1}_{0}n + 4\,{}^{0}_{0}\gamma$$

(A) $^{141}_{52}Te$　(B) $^{144}_{54}Xe$　(C) $^{143}_{54}Xe$　(D) $^{143}_{52}Te$　(E) $^{92}_{38}Sr$

24. Which of the following undergo nitration faster than benzene?



(A) 4 and 5　(B) 2, 3, and 5　(C) 1 and 2　(D) 3 and 4　(E) 1, 4, and 5

25. What is the maximum motional contribution (including translational, rotational, and vibrational degrees of freedom) to the molar internal energy of gaseous CO_2, assuming ideal gas behavior?

(A) 6 RT　(B) 6.5RT　(C) 3.5RT　(D) 3RT　(E) 2.5RT

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26. Consider two flasks at 100°C, one contains an ideal gas and the other contains the real gas SO_3. Which statement regarding these gases is **TRUE**?

(A) As the temperature is increased, the pressure of the ideal gas will be smaller than the pressure of SO_3 because the van der Waals coefficient ***a*** for SO_3 is large.

(B) As the temperature is decreased, the ideal gas will liquefy first because ideal gases have larger values of the van der Waals coefficient ***b***.

(C) As the temperature is decreased, the pressure of the ideal gas will be smaller than the pressure of SO_3 because the van der Waals coefficient ***b*** for SO_3 is large.

(D) As the temperature is decreased, the volume of the ideal gas will be larger than the volume of SO_3 because the van der Waals coefficient ***a*** for SO_3 is large.

(E) As the temperature is increased, the volume of the ideal gas will be smaller than the volume of SO_3 because ideal gases have larger values of the van der Waals coefficient ***a***.

27. The enthalpy change due to the reaction of one mole of C_2H_4 with water to form C_2H_5OH can be estimated by

(A) BE(C-C) + BE(O-H) - 2BE(C-O) - BE(C-H)

(B) BE(C=C) + BE(O-H) - 2BE(C-C) - BE(C-O)

(C) BE(C-H) + BE(C-O) - BE(C-C) - BE(O-H)

(D) BE(O-H) + BE(C=C) - BE(C-H) - BE(C-O) - BE(C-C)

(E) BE(C-H) + BE(C-O) + BE(C-C) - BE(O-H) - BE(C=C)

28. Arrange these compounds in order of increasing standard molar entropy at 25°C: $C_3H_8(g)$, $C_2H_4(g)$, ZnS(s), and $H_2O(l)$.

(A) $ZnS(s) < H_2O(l) < C_2H_4(g) < C_3H_8(g)$

(B) $C_2H_4(g) < H_2O(l) < C_3H_8(g) < NaCl(s)$

(C) $ZnS(s) < C_3H_8(g) < C_2H_4(g) < H_2O(l)$

(D) $C_3H_8(g) < C_2H_4(g) < H_2O(l) < ZnS(s)$

(E) $ZnS(s) < H_2O(l) < C_3H_8(g) < C_2H_4(g)$

29. The normal freezing point of ammonia is -78°C. Predict the signs of ΔH, ΔS, and ΔG for ammonia when it freezes at -80°C and 1 atm: $NH_3(l) \rightarrow NH_3(s)$

	ΔH	ΔS	ΔG
A.	−	−	0
B.	−	+	−
C.	+	−	+
D.	+	+	0
E.	−	−	−

(A) Choice A　(B) Choice B　(C) Choice C　(D) Choice D　(E) Choice E

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30. Calculate the standard free energy of formation of mercury(II) oxide at 298 K, given

	HgO(s)	Hg(l)	O_2(g)
$\Delta H_f°$, kJ·mol^{-1}	–90.83	–	–
$S_m°$, J·K^{-1}·mol^{-1}	70.29	76.02	205.14

(A) +58.5 kJ/mol (B) +117.1 kJ/mol (C) –58.5 kJ/mol
(D) –123.1 kJ/mol (E) –117.1 kJ/mol

31. For the reaction

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$

$\Delta H_r° = +52.3$ kJ·mol^{-1} and $\Delta S_r° = -53.07$ J·K^{-1}·mol^{-1} at 298 K. This reaction will be spontaneous at
(A) no temperature. (B) all temperatures. (C) temperatures below 985 K.
(D) temperatures above 985 K. (E) temperatures below 1015 K.

32. A solution of chloroform ($CHCl_3$) and acetone($(CH_3)_2CO$) exhibits a negative deviation from Raoult's law. This result implies that
(A) chloroform-chloroform interactions are stronger than chloroform-acetone interactions.
(B) chloroform-chloroform interactions are weaker than chloroform-acetone interactions.
(C) acetone-acetone interactions are stronger than chloroform-acetone interactions.
(D) a solution of chloroform and acetone may exits a low-boiling azeotrope.
(E) None is correct.

33. If the standard potentials of Cu^{2+} and Cu^+ are +0.34 and +0.54 V, respectively, please calculate $E°$of the following half reaction:

$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$

(A) +0.20 V (B) -0.20 V (C) +0.68 V (D) –0.14 V (E) +0.14 V

34. At 10°C one volume of water dissolves 3.10 volumes of chlorine gas at 1.00 atm pressure. What is the Henry's Law constant in mol/L·atm?
(A) 0.043 (B) 3.1 (C) 0.13 (D) 3.8 (E) 36.

35. If $E°$ for the following cell is 0.36 V at 25°C

$Pb(s)\,|\,PbSO_4(s)\,|\,SO_4^{2-}(aq, 0.90\ M)\,\|\,H^+(aq, 1.20\ M)\,|\,H_2(g, 271.2\ kPa)\,|\,Pt$

How is the Nernst equation for the cell properly expressed at this temperature?
(A) $E = 0.36 - 0.01285 \cdot \ln[2.712/\{(1.20)^2(0.90)\}]$
(B) $E = 0.36 - 0.02569 \cdot \ln[271.2/\{(1.20)(0.90)\}]$
(C) $E = 0.36 - 0.01285 \cdot \ln[271.2/\{(1.20)^2(0.90)\}]$
(D) $E = 0.36 + 0.01285 \cdot \ln[271.2/\{(1.20)^2(0.90)\}]$
(E) $E = 0.36 - 0.02569 \cdot \ln[2.712/\{(1.20)(0.90)\}]$

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36. Consider the following reaction:

$Ni(CO)_4(g) \rightarrow Ni(s) + 4CO(g)$

If the initial concentration of $Ni(CO)_4(g)$ is 1.0 *M*, and X is the equilibrium concentration of CO(g), what is the correct equilibrium relation?

(A) $K_c = X^4/(1.0 - 4X)$　(B) $K_c = X^4/(1.0 - X/4)$　(C) $K_c = X/(1.0 - X/4)$

(D) $K_c = X^5/(1.0 - X/4)$　(E) $K_c = 4X/(1.0 - 4X)$

37. Which one of the following sets of quantum numbers is not possible?

	n	l	m_l	m_s
A.	4	3	−2	+1/2
B.	3	2	−3	−1/2
C.	3	0	0	+1/2
D.	4	1	1	−1/2
E.	2	0	0	+1/2

(A) Choice A　(B) Choice B　(C) Choice C　(D) Choice D　(E) Choice E

38. Which of the following statements is true?

(A) A d-electron penetrates more than an s-electron through the inner shells of an atom.

(B) A d-orbital has a spherical boundary surface.

(C) An electron in an s-orbital has a zero probability of being found at the nucleus.

(D) A p-electron experiences a smaller effective nuclear charge than an s-electron.

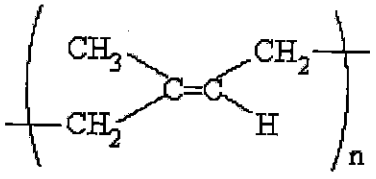
(E) With the same principle quantum number, s-electron is more delocalized than f-electron.

39. Which of the following compounds is optically active?

(A) $NH_2C(CH_3)_2COOH$　(B) $CH_3CHCH(Cl)$　(C) $CH_3CH_2CH(NH_2)COOH$

(D) CH_3OCH_3　(E) $(CH_3)_2CHCONH_2$

40. The structure of rubber, a polymer, is



What is the formula of the monomer used to produce rubber?

(A) $(CH_3)_2CCHCH_3$　(B) CH_3CCCH_3　(C) CH_2CCCH_2　(D) $CH_2C(CH_3)CHCH_2$

(E) $CH_3CH(CH_3)CH_2CH_3$

參考用