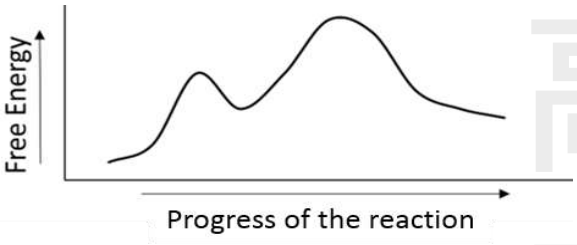
111 學年度學士後醫學系招生考試
化學 試題

Choose one best answer for the following questions

【單選題】每題 1 分，共計 30 分，答錯 1 題倒扣 0.25 分，倒扣至本大題零分為止，未作答，不給分亦不扣分。1~15 題為物理，16~30 題為化學。

16. In the given reaction coordinate diagram, how many intermediate(s) is/are presented?



(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

17. How many nanometers is equal to 7.6 meters?

(A) 76×10^{7} (B) 76×10^{8} (C) 76×10^{9} (D) 76×10^{-8} (E) 76×10^{-9}

18. A specific type of nucleus has a half-life of 40 min. How long is required for 80% of the nuclides to decompose? (ln2 = 0.693; ln0.2 = -1.609)

(A) 80 min (B) 85 min (C) 95 min (D) 102 min (E) 120 min

19. Which of the following ionic compounds has the largest lattice energy (i.e., the lattice energy most favorable to a stable lattice)?

(A) MgO (B) CaO (C) Li_2O (D) Na_2O (E) K_2O

20. Determine the hybridization of Cl in ClF_2^-.

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

21. Determine, respectively, the proper formulas for sodium tetrachloroaluminate(III) and sodium tetrachlorocobaltate(II).

(A) $Na(AlCl_4)$; $Na_2(CoCl_4)$ (B) $Na(AlCl_4)$; $Na(CoCl_4)$ (C) $Na_2(AlCl_4)$; $Na(CoCl_4)$
(D) $Na_2(AlCl_4)$; $Na_2(CoCl_4)$ (E) $Na_3(AlCl_4)$; $Na_2(CoCl_4)$

22. What is the sum of all coefficients when the following equation is balanced?

$NH_3(g) + O_2(g) \rightarrow NO_2(g) + H_2O(g)$

(A) 6 (B) 14 (C) 17 (D) 21 (E) 23

23. A compound is composed of element X and hydrogen. A mass analysis shows the compound contains 82.35% of X, with three times as many hydrogen atoms as X atoms per molecule. Which element is X? (atomic mass: B = 10.81, C = 12.01, N = 14.01, Al = 26.98, P = 30.97)

(A) B (B) C (C) N (D) Al (E) P

111 學年度學士後醫學系招生考試
化學　試題

24. Which of the following statements is ***incorrect***?
(A) Heteronuclear linear molecules can have a net dipole moment.
(B) A molecular dipormenant is the dipole moment of the molecular taken as a whole.
(C) Ionic bonding results from the transfer of electrons from one atom to another.
(D) A molecule with polar bonds must be polar.
(E) The distribution of electrons in a polar bond is closer to the more electronegative element.

25. Regarding to the concept of reduction and oxidation, which of the following statements is ***true***?
(A) All chemical changes is accompanied by reduction and oxidation.
(B) When the atom is oxidized, the size becomes larger.
(C) The oxidizing agent is electron donor.
(D) Reduction and oxidation can occur independently of each other.
(E) Reduction and oxidation describe the gain and loss of electron(s), respectively.

26. You have immersed electrodes of a light bulb in a solution of H_2SO_4 such that the light bulb is on. You add a dilute solution and the bulb grows dim. Which of the following molecule could be in the solution?
(A) $Cu(NO_3)_2$ (B) K_2SO_4 (C) $NaNO_3$ (D) $ZnCl_2$ (E) $Pb(NO_3)_2$

27. Which of the following anions is the most basic?
(A) ClO^- (B) ClO_2^- (C) ClO_3^- (D) ClO_4^- (E) Cl^-

28. Which of the following element or ions is the largest in size?
(A) O^{2-} (B) F^- (C) Ne (D) Na^+ (E) Mg^{2+}

29. Which of the following molecules has the largest dipole moment?
(A) CO_2 (B) Cl_2 (C) XeF_4 (D) SF_4 (E) BF_3

30. I. The hybridization of boron in BF_3 is sp^3.
II. The molecule of I_3^- is polar.
III. The bond order of N_2 molecule is two.
IV. The molecule of HCN has one pi bond and two sigma bonds.
Which is ***true***?
(A) All four statements are correct.
(B) II is incorrect.
(C) I and IV are incorrect.
(D) II and III are incorrect.
(E) All four statements are incorrect.

【單選題】每題 2 分，共計 120 分，答錯 1 題倒扣 0.5 分，倒扣至本大題零分為止，未作答，不給分亦不扣分。31~60 題為物理，61~90 題為化學。

111 學年度學士後醫學系招生考試
化學　試題

61. When a certain atom emits a photon of light at 232 nm, what is the frequency of this light?
(A) $1.29 \times 10^{15}\ s^{-1}$ (B) $1.15 \times 10^{15}\ s^{-1}$ (C) $1.15 \times 10^{-15}\ s^{-1}$
(D) $76.7\ s^{-1}$ (E) None of the above.

62. Given a cylinder of fixed volume filled with 1 mol of argon gas, which of the following is ***correct***? (Assume all gases obey the ideal gas law.)
(A) If the temperature of the cylinder is changed from 25°C to 50°C, the pressure inside the cylinder will remain the same.
(B) If a second mole of argon is added to the cylinder, the ratio of T/P would decrease.
(C) A cylinder of identical volume filled with the same pressure of helium must contain more atoms of gas, because helium has a smaller atomic radius than argon.
(D) Two of the above.
(E) None of the above.

63. Which of the following statements is ***true***?
(A) The energy of electromagnetic radiation increases as its frequency decreases.
(B) An electron in the n = 4 state in the hydrogen atom can go to the n = 2 state by absorbing electromagnetic radiation at the appropriate frequency.
(C) The frequency and wavelength of electromagnetic radiation are proportional to each other.
(D) The energy of an atom is increased when electromagnetic radiation is emitted from it.
(E) An excited atom can return to its ground state by emitting electromagnetic radiation.

64. What is the hybridization of the central carbon atom of allene ($H_2C{=}C{=}CH_2$)?
(A) sp (B) sp^2 (C) sp^3 (D) dsp^3 (E) d^2sp^3

65. How many of the following molecules have all of their atoms in the same plane?
$H_2C{=}CH_2$, $H_2C{=}C{=}CH_2$, CH_3COCH_3, NH_3, CO_2, $BeCl_2$
(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

66. Which of these species, O_2^-, O_2, and O_2^+, should be paramagnetic?
(A) O_2^+ and O_2^- (B) O_2^+ and O_2 (C) O_2 and O_2^- (D) only O_2
(E) All three are paramagnetic.

67. Based on the molecular orbital theory, which of the following molecules has the strongest bond?
(A) NO^+ (B) NO (C) NO^- (D) NO^{2-}
(E) All the above molecules have the same bond strength.

111 學年度學士後醫學系招生考試
化學　試題

68. Which of the following molecules has the smallest bond angle?
(A) CH_4 (B) SiH_4 (C) NH_3 (D) H_2O (E) H_2S

69. Which of the following statements is ***false***?
(A) The layering in a hexagonal closest-packed structure is *aba*.
(B) A body-centered cubic unit cell has two atoms per unit cell.
(C) For unit cells having the same edge length, a simple cubic structure would have a smaller density than a body-centered cube.
(D) The size of tetrahedral hole is always larger than the size of octahedral hole.
(E) Atoms in a solid, consisting of only one element would have six nearest neighbors if the crystal structure was a simple cubic array.

70. Rank the following compounds in the order from the highest boiling point to the lowest boiling point.
(a) $C_2H_5OC_2H_5$ (b) CH_3OH (c) $HCONH_2$ (d) HCOOH
(A) (b) > (a) > (c) > (d) (B) (b) > (a) > (d) > (c)
(C) (c) > (d) > (b) > (a) (D) (d) > (c) > (b) > (a)
(E) (b) > (d) > (a) > (c)

71. The reaction "A + 2B → 2 C" exhibits the rate law as following: Rate = k [A][B]^2
Which of the following mechanisms could be consistent with this rate law?
(A) A + 2B → D (fast), D → 2 C (slow)
(B) 2B → D (fast), D + A → 2 C (slow)
(C) 2B → D (slow), A + D → E (fast), E → 2 C (fast)
(D) A + B ⇌ D (fast equilibrium), B + D → 2 C (slow)
(E) B ⇌ 2 D (fast equilibrium), D + A → C (slow)

72. Consider the following reaction:
$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$, equilibrium constant (K) = $6.0 \times 10^{-2}\ M^{-2}$ at 500 °C.
Predict the reaction direction of the following cases:
a. $[N_2] = 1.00 \times 10^{-2}$ M; $[H_2] = 3.00 \times 10^{-2}$ M; $[NH_3] = 6.00 \times 10^{-4}$ M
b. $[N_2] = 1.00 \times 10^{-3}$ M; $[H_2] = 4.00 \times 10^{-2}$ M; $[NH_3] = 1.00 \times 10^{-5}$ M
c. $[N_2] = 1.00 \times 10^{-5}$ M; $[H_2] = 5.00 \times 10^{-1}$ M; $[NH_3] = 2.00 \times 10^{-4}$ M
(A) a. No shift; b. shift to left; c. shift to right
(B) a. No shift; b. shift to right; c. shift to left
(C) a. Shift to right; b. shift to left; c. no shift
(D) a. Shift to right; b. shift to right; c. shift to right
(E) a. Shift to left; b. shift to right; c. shift to left

111 學年度學士後醫學系招生考試
化學 試題

73. Consider the following reaction at equilibrium. Which change will cause the equilibrium to shift to the left?

$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, $\Delta H^o_{rxn} = +30$ kJ/mol

(A) Increase the container volume (B) Remove some NO
(C) Decrease the temperature (D) Add more NOBr
(E) Increase the temperature

74. How many of the following will raise the pH of a weak acid HA in aqueous solution?

I. Addition of water.
II. Making a buffered solution by adding NaA(*s*).
III. Addition of NaCl(*s*).
IV. Addition of HNO_3.
V. Titrating with KOH.

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

75. What is the point group of triphenylphosphine?

(A) D_{3d} (B) D_3 (C) D_{3h} (D) C_3 (E) C_{3v}

76. Consider a galvanic cell based on the following reactions:

$2\ Au^{3+} + 3\ Mg \rightarrow 2\ Au + 3\ Mg^{2+}$

The reduction potentials for Au^{3+} and Mg^{2+}:

$Au^{3+} + 3\ e^- \rightarrow Au$, $\varepsilon^o = 1.5$ V

$Mg^{2+} + 2\ e^- \rightarrow Mg$, $\varepsilon^o = -2.37$ V

What is the value of ΔG^o?

(A) -84 kJ (B) -373 kJ (C) -746 kJ (D) -1120 kJ (E) -2240 kJ

77. What type of radioactive process would be expected in the following reaction?

$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa$

(A) α particle production (B) β particle production (C) positron production
(D) γ ray production (E) electron capture

78. Which of the following complexes can exhibit optical isomerism?

(A) *cis*-$Co(NH_3)_4Cl_2$ (B) *trans*-$Co(en)_2Br_2$ (C) *cis*-$Co(en)_2Cl_2$
(D) $Co(NH_3)_3Cl_3$ (E) None of the above.

79. Which one of the following is paramagnetic?

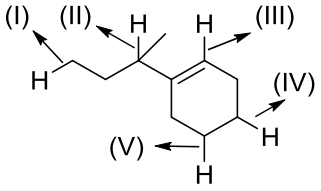
(A) $Zn(H_2O)_6^{2+}$ (B) $Co(NH_3)_6^{3+}$ (C) $Cu(CN)_3^{2-}$ (D) $Mn(CN)_6^{2-}$ (E) $Fe(SCN)_6^{2+}$

111 學年度學士後醫學系招生考試
化學　試題

80. A formula of a certain compound is $[M(NH_3)_5Cl]Cl_2$, where the M is a type of metal. The metal ion has 24 electrons in this complex. Determine the identity of the metal.
(A) Mn (B) Fe (C) Co (D) Ni (E) Cu

81. Two well-known complex ions containing Ni are $[Ni(H_2O)_6]^{2+}$, which is green, and $[Ni(en)_3]^{2+}$, which is purple. Which one of the following statements is ***true***?
(A) The crystal field splitting energy (Δ) is greater for $[Ni(en)_3]^{2+}$ than for $[Ni(H_2O)_6]^{2+}$.
(B) $[Ni(en)_3]^{2+}$ absorbs energy in the red region of the spectrum.
(C) Both complex ions are diamagnetic.
(D) $[Ni(H_2O)_6]^{2+}$ transmits light with wavelengths of approximately 650–700 nm.
(E) The green complex absorbs green light.

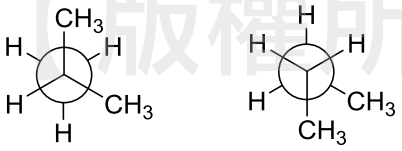
82. Which of the labeled C-H bond is the weakest?



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

83. Which of the following alkenes generates the greatest heat upon hydrogenation?
(A) 1,3-pentadine (B) 1,4-pentadiene (C) 1,3-butadiene
(D) *cis*-2-pentene (E) *trans*-2-pentene

84. What is the structural relationship of the following two compounds?

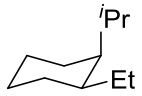


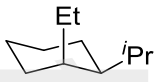
(A) not isomers (B) conformational isomers
(C) *cis-trans* isomers (D) structural isomers
(E) both conformational isomers and structural isomers

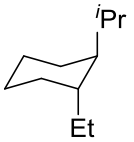
85. A tetracyclic compound, aldrin ($C_{12}H_8Cl_6$), was used as an insecticide. How many double bonds are presented in aldrin?
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

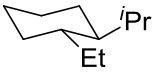
111 學年度學士後醫學系招生考試
化學　試題

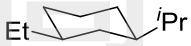
86. Which of following structures presents the most stable conformation of *cis*-1-ethyl-2-isopropylcyclohexane?

(A) 

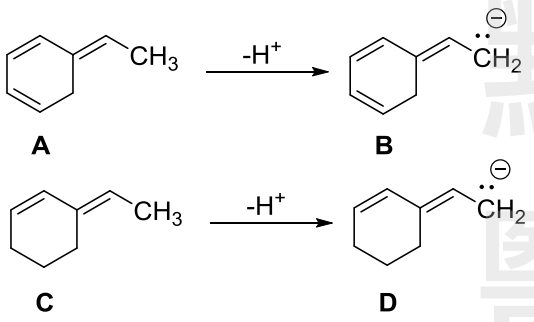
(B) 

(C) 

(D) 

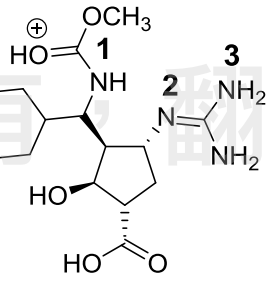
(E) 

87. Determine the most acidic compound shown below.



(A) A　(B) B　(C) C　(D) D
(E) There is not enough information to determine the acidic order.

88. Peramivir has shown to be effective against the influenza B virus. Rank following nitrogen atoms in the order from the strongest base to the weakest base.



(A) 1 > 3 > 2　(B) 2 > 1 > 3　(C) 2 > 3 > 1　(D) 3 > 2 > 1　(E) 3 > 1 = 2

89. Arrange the following arenes in the decreasing reactivity toward HNO_3/H_2SO_4.
(a) PhH　(b) PhCl　(c) $PhCO_2H$　(d) $PhCH_3$
(A) (c) > (d) > (b) > (a)　(B) (a) > (b) > (d) > (c)　(C) (d) > (a) > (b) > (c)
(D) (d) > (b) > (a) > (c)　(E) (a) > (b) > (c) > (d)

111 學年度學士後醫學系招生考試
化學　試題

90. Which compound exhibits only two signals in its ^1H NMR spectrum, a triplet and a quintet?

(A) $BrCH_2CH_2CH_2Br$　(B) $BrCH_2CH_2CH_2Cl$　(C) $(CH_3)_2CHCH(CH_3)_2$

(D) $CH_3CH_2CH_2CH_3$　(E) $(CH_3)_2CHOCH(CH_3)_2$

後醫-物理及化學

題號	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
答案	C	E	D	E	C	A	B	B	A	A	B	D	E	C	D	B	B	C	A	D
題號	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
答案	A	D	C	D	E	E	A	A	D	E	D	B	D	E	E	A	E	C	A	E
題號	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
答案	D	A	A	C	C	E	B	B	C	A	C	D	C	C	E	A	C	B	A	B
題號	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
答案	A	B	E	A	B	E	A	E	D	C	D	D	C	C	D	E	B	C	D	C
題號	81	82	83	84	85	86	87	88	89	90										
答案	A	B	B	D	B	B	A	C	C	A										

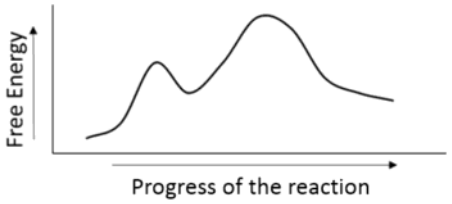
高雄醫學大學 111 學年度學士後醫學系招生考試試題參考答案疑義釋疑公告

科目	題號	釋疑答覆	釋疑結果
化學	18	本題計算結果區間為 93 min ~ 95 min,因此選項(c) 95 min 為最佳答案。	答案不變 (C)
	71	(A) D → 2C 為速率決定步驟,並無法獲得 Rate=k[A][B]^2 (B) D+A → 2C 為速率決定步驟,也無法獲得 Rate=k[A][B]^2 因此僅有(D)選項為正確答案。	答案不變 (D)
	74	題意為下列共有幾個選項會提高原弱酸(HA)水溶液的 pH 值。其選項 II 為加入 NaA(s)去製備緩衝溶液：原弱酸(HA)水溶液有較低的 pH 值,在加入 NaA(s)的過程中會提高其溶液的 pH 值,此選項為正確選項。答案仍維持(C)。	答案不變 (C)

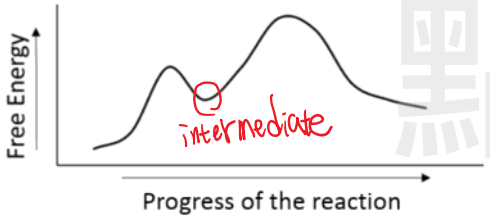
化　學

梁傑(梁家榮)老師提供

B 16. In the given reaction coordinate diagram, how many intermediate(s) is/are presented?



(A) 0 (B) 1 (C) 2 (D) 3 (E) 4



B 17. How many nanometers is equal to 7.6 meters?

(A) 76×10^{7} (B) 76×10^{8} (C) 76×10^{9} (D) 76×10^{-8} (E) 76×10^{-9}

$$7.6\ m \times \frac{1\ nm}{10^{-9}\ m} = 7.6 \times 10^{9}\ nm = 76 \times 10^{8}\ nm$$

C 18. A specific type of nucleus has a half-life of 40 min. How long is required for 80% of the nuclides to decompose? ($\ln 2 = 0.693$; $\ln 0.2 = -1.609$)

(A) 80 min (B) 85 min (C) 95 min (D) 102 min (E) 120 min

$$\ln\left(\frac{100}{20}\right) = \left(\frac{\ln 2}{40}\right) \times t \Rightarrow t = 92.8\ min$$

A 19. Which of the following ionic compounds has the largest lattice energy (i.e., the lattice energy most favorable to a stable lattice)?

(A) MgO (B) CaO (C) Li_2O (D) Na_2O (E) K_2O

電量較大且半徑相對小的陰陽離子形成的 ionic cpd 會有較大的 lattice energy

D 20. Determine the hybridization of Cl in ClF_2^-.

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

混成：dsp^3

21. Determine, respectively, the proper formulas for sodium tetrachloroaluminate(III) and sodium tetrachlorocobaltate(II).

A

(A) $Na(AlCl_4)$; $Na_2(CoCl_4)$ (B) $Na(AlCl_4)$; $Na(CoCl_4)$ (C) $Na_2(AlCl_4)$; $Na(CoCl_4)$
(D) $Na_2(AlCl_4)$; $Na_2(CoCl_4)$ (E) $Na_3(AlCl_4)$; $Na_2(CoCl_4)$

$Na(AlCl_4)$ = sodium tetrachloroaluminate(III)

$Na_2(CoCl_4)$ = sodium tetrachlorocobaltate(II)

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22. What is the sum of all coefficients when the following equation is balanced?

D

$NH_3(g) + O_2(g) \rightarrow NO_2(g) + H_2O(g)$

(A) 6 (B) 14 (C) 17 (D) 21 (E) 23

$4NH_3 + 7O_2 \longrightarrow 4NO_2 + 6H_2O$

---

23. A compound is composed of element X and hydrogen. A mass analysis shows the compound contains 82.35% of X, with three times as many hydrogen atoms as X atoms per molecule. Which element is X? (atomic mass: B = 10.81, C = 12.01, N = 14.01, Al = 26.98, P = 30.97)

C

(A) B (B) C (C) N (D) Al (E) P

$X : H = \frac{82.35}{AW} : \frac{17.65}{1} = 1 : 3 \Rightarrow AW = 14$ (該元素為 nitrogen)

---

24. Which of the following statements is ***incorrect***?

D

(A) Heteronuclear linear molecules can have a net dipole moment.
(B) A molecular dipormenant is the dipole moment of the molecular taken as a whole.
(C) Ionic bonding results from the transfer of electrons from one atom to another.
(D) A molecule with polar bonds must be polar.
(E) The distribution of electrons in a polar bond is closer to the more electronegative element.

含有 polar bond 的分子不一定具有極性

例如: CO_2 就是含有 polar bond 的非極性分子

---

25. Regarding to the concept of reduction and oxidation, which of the following statements is ***true***?

E

(A) All chemical changes is accompanied by reduction and oxidation.
(B) When the atom is oxidized, the size becomes larger.
(C) The oxidizing agent is electron donor.
(D) Reduction and oxidation can occur independently of each other.
(E) Reduction and oxidation describe the gain and loss of electron(s), respectively.

(A) 錯誤，並非所有化學反應都是氧化還原反應，也有可能屬於酸鹼反應或沉澱反應

(B) 錯誤，當某原子發生氧化而失去電子，size 通常都變小

(例如: Na 氧化變成 Na^+，Na^+半徑變小)

(C) 錯誤，氧化劑是電子的接受者 (electron acceptor)

(D) 錯誤，氧化還原反應必定相伴發生

(E) 正確

E

26. You have immersed electrodes of a light bulb in a solution of H_2SO_4 such that the light bulb is on. You add a dilute solution and the bulb grows dim. Which of the following molecule could be in the solution?

(A) $Cu(NO_3)_2$ (B) K_2SO_4 (C) $NaNO_3$ (D) $ZnCl_2$ (E) $Pb(NO_3)_2$

$Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4(s)\downarrow$

本題主要想測驗同學對於 Pb^{2+} 和 SO_4^{2-} 相遇會產生不溶性固體 $PbSO_4$ 的概念

考試時一定優先選(E)沒錯

但燈泡是否變暗取決於溶液中能夠導電的離子總濃度是否變少

雖然兩溶液混合可能會造成體積增加而使總離子濃度下降

但反應前 H_2SO_4 並未完全解離(要記得H_2SO_4第一段100%解離但第二段無法完全解離)

而反應後雖然產生 $PbSO_4$ 沉澱，但溶液中剩下可完全解離的 H^+和NO_3^- 可以導電

因此反應前後離子總濃度是否變少尚有爭議

A

27. Which of the following anions is the most basic?

(A) ClO^- (B) ClO_2^- (C) ClO_3^- (D) ClO_4^- (E) Cl^-

HClO的酸性比 $HClO_2$、$HClO_3$、$HClO_4$ 或 HCl更弱

因此 ClO^- 鹼性比 ClO_2^-、ClO_3^-、ClO_4^- 或 Cl^- 更強

A

28. Which of the following element or ions is the largest in size?

(A) O^{2-} (B) F^- (C) Ne (D) Na^+ (E) Mg^{2+}

半徑大小: $O^{2-} > F^- > Ne > Na^+ > Mg^{2+}$

D

29. Which of the following molecules has the largest dipole moment?

(A) CO_2 (B) Cl_2 (C) XeF_4 (D) SF_4 (E) BF_3

$\mu = 0$: CO_2、Cl_2、XeF_4、BF_3

$\mu \neq 0$: SF_4

三

30. I. The hybridization of boron in BF_3 is sp^3.

II. The molecule of I_3^- is polar.

III. The bond order of N_2 molecule is two.

IV. The molecule of HCN has one pi bond and two sigma bonds.

Which is ***true***?

(A) All four statements are correct. (B) II is incorrect.

(C) I and IV are incorrect. (D) II and III are incorrect.

(E) All four statements are incorrect.

(I)錯誤，BF_3 為 sp^2 混成

(II)錯誤，I_3^- 沒有極性

(III)錯誤，N_2 的 bond order = 3

(IV)錯誤，HCN 擁有 1 組 sigma bond 和 2 組 pi bond

61. When a certain atom emits a photon of light at 232 nm, what is the frequency of this light?

(A) $1.29 \times 10^{15}\ s^{-1}$ (B) $1.15 \times 10^{15}\ s^{-1}$ (C) $1.15 \times 10^{-15}\ s^{-1}$

(D) $76.7\ s^{-1}$ (E) None of the above.

A

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^{8}\ m/s}{232 \times 10^{-9}\ m} = 1.29 \times 10^{15}\ \frac{1}{s}$$

---

62. Given a cylinder of fixed volume filled with 1 mol of argon gas, which of the following is ***correct***? (Assume all gases obey the ideal gas law.)

(A) If the temperature of the cylinder is changed from 25°C to 50°C, the pressure inside the cylinder will remain the same.

(B) If a second mole of argon is added to the cylinder, the ratio of T/P would decrease.

(C) A cylinder of identical volume filled with the same pressure of helium must contain more atoms of gas, because helium has a smaller atomic radius than argon.

(D) Two of the above.

(E) None of the above.

B

(A) 錯誤，$PV = nRT \Rightarrow T\uparrow, P\uparrow$

(B) 正確，$V = nR\left(\frac{T}{P}\right) \Rightarrow n\uparrow, \frac{T}{P}\downarrow$

(C) 錯誤，同溫同壓且同體積的 ideal gas，擁有相同粒子數量

---

63. Which of the following statements is ***true***?

(A) The energy of electromagnetic radiation increases as its frequency decreases.

(B) An electron in the n = 4 state in the hydrogen atom can go to the n = 2 state by absorbing electromagnetic radiation at the appropriate frequency.

(C) The frequency and wavelength of electromagnetic radiation are proportional to each other.

(D) The energy of an atom is increased when electromagnetic radiation is emitted from it.

(E) An excited atom can return to its ground state by emitting electromagnetic radiation.

E

(A)錯誤，電磁輻射的能量與頻率應成正比關係

(B)錯誤，氫原子上的電子由 n=4 降落到 n=2 時應「放出」電磁輻射

(C)錯誤，頻率和波長應成反比關係

(D)錯誤，當某原子釋放電磁輻射，該原子的能量應下降

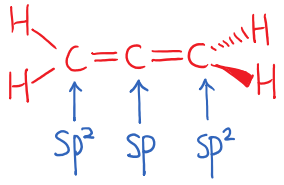
(E)正確

---

64. What is the hybridization of the central carbon atom of allene ($H_2C{=}C{=}CH_2$)?

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

A



B

65. How many of the following molecules have all of their atoms in the same plane?

$H_2C{=}CH_2$, $H_2C{=}C{=}CH_2$, CH_3COCH_3, NH_3, CO_2, $BeCl_2$

(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

所有原子共平面的分子: $H_2C{=}CH_2$、CO_2、$BeCl_2$

至少有一個原子不共平面的分子: $H_2C{=}C{=}CH_2$、CH_3COCH_3、NH_3

E

66. Which of these species, O_2^-, O_2, and O_2^+, should be paramagnetic?

(A) O_2^+ and O_2^- (B) O_2^+ and O_2 (C) O_2 and O_2^- (D) only O_2

(E) All three are paramagnetic.

O_2^- 和 O_2^+ 的價電子總數為奇數，必定屬於順磁分子

O_2 雖然價電子總數為偶數，但可由其分子軌域看出 O_2 含有 2 個未成對電子，也屬於順磁分子

A

67. Based on the molecular orbital theory, which of the following molecules has the strongest bond?

(A) NO^+ (B) NO (C) NO^- (D) NO^{2-}

(E) All the above molecules have the same bond strength.

	NO^+	NO	NO^-	NO^{2-}
價電子總數	10	11	12	13
Bond order	3	2.5	2	1.5

(鍵長最短)

E

68. Which of the following molecules has the smallest bond angle?

(A) CH_4 (B) SiH_4 (C) NH_3 (D) H_2O (E) H_2S

鍵角: $CH_4 = SiH_4 > NH_3 > H_2O > H_2S$

109.5° 109.5° 107° 104.5° ≈90°

↑中心原子混成軌域的 s-ch很小

D

69. Which of the following statements is ***false***?

(A) The layering in a hexagonal closest-packed structure is *aba*.

(B) A body-centered cubic unit cell has two atoms per unit cell.

(C) For unit cells having the same edge length, a simple cubic structure would have a smaller density than a body-centered cube.

(D) The size of tetrahedral hole is always larger than the size of octahedral hole.

(E) Atoms in a solid, consisting of only one element would have six nearest neighbors if the crystal structure was a simple cubic array.

(D)錯誤，tetrahedral hole 的 size 小於 octahedral hole

---

70. Rank the following compounds in the order from the highest boiling point to the lowest boiling point.

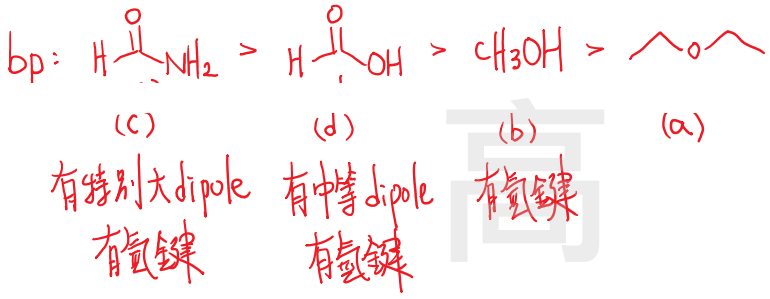
C

(a) $C_2H_5OC_2H_5$ (b) CH_3OH (c) $HCONH_2$ (d) $HCOOH$

(A) (b) > (a) > (c) > (d) (B) (b) > (a) > (d) > (c)

(C) (c) > (d) > (b) > (a) (D) (d) > (c) > (b) > (a)

(E) (b) > (d) > (a) > (c)



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71. The reaction "A + 2B → 2 C" exhibits the rate law as following: Rate = k [A][B]^2

Which of the following mechanisms could be consistent with this rate law?

D

(A) A + 2B → D (fast), D → 2 C (slow)

(B) 2B → D (fast), D + A → 2 C (slow)

(C) 2B → D (slow), A + D → E (fast), E → 2 C (fast)

(D) A + B ⇌ D (fast equilibrium), B + D → 2 C (slow)

(E) B ⇌ 2 D (fast equilibrium), D + A → C (slow)

$$k_1[A]^1[B]^1 = k_{-1}[D] \Rightarrow [D] = \frac{k_1}{k_{-1}}[A]^1[B^1]$$

$$Rate = k_2[B]^1[D]^1 = k_2[B] \times \left(\frac{k_1}{k_{-1}}[A]^1[B^1]\right) = \left(\frac{k_1 k_2}{k_{-1}}\right)[A]^1[B]^2 = k[A]^1[B]^2$$

備註：(B)選項有些許爭議，但出題老師不願意給分

---

72. Consider the following reaction:

$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$, equilibrium constant (K) = $6.0 \times 10^{-2}\ M^{-2}$ at 500 °C.

Predict the reaction direction of the following cases:

D

a. $[N_2] = 1.00 \times 10^{-2}$ M; $[H_2] = 3.00 \times 10^{-2}$ M; $[NH_3] = 6.00 \times 10^{-4}$ M

b. $[N_2] = 1.00 \times 10^{-3}$ M; $[H_2] = 4.00 \times 10^{-2}$ M; $[NH_3] = 1.00 \times 10^{-5}$ M

c. $[N_2] = 1.00 \times 10^{-5}$ M; $[H_2] = 5.00 \times 10^{-1}$ M; $[NH_3] = 2.00 \times 10^{-4}$ M

(A) a. No shift; b. shift to left; c. shift to right

(B) a. No shift; b. shift to right; c. shift to left

(C) a. Shift to right; b. shift to left; c. no shift

(D) a. Shift to left; b. shift to right; c. shift to right

(E) a. Shift to left; b. shift to right; c. shift to left

a: $Q=\frac{(6\times10^{-4})^2}{(1\times10^{-2})(3\times10^{-2})^3}=1.33>K$ (shift to left)

b: $Q=\frac{(1\times10^{-5})^2}{(1\times10^{-3})(4\times10^{-2})^3}=6.25\times10^{-3}<K$ (shift to right)

c: $Q=\frac{(2\times10^{-4})^2}{(1\times10^{-5})(5\times10^{-1})^3}=3.2\times10^{-2}<K$ (shift to right)

---

73. Consider the following reaction at equilibrium. Which change will cause the equilibrium to shift to the left?

C $2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, $\Delta H°_{rxn} = +30$ kJ/mol

(A) Increase the container volume (B) Remove some NO
(C) Decrease the temperature (D) Add more NOBr
(E) Increase the temperature

降溫可使吸熱反應的平衡向左

---

74. How many of the following will raise the pH of a weak acid HA in aqueous solution?

I. Addition of water.
C II. Making a buffered solution by adding NaA(*s*).
III. Addition of NaCl(*s*).
IV. Addition of HNO_3.
V. Titrating with KOH.

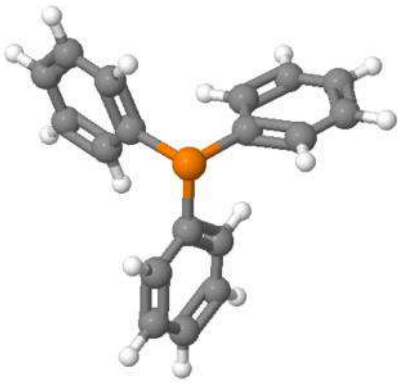
(A) 5 (B) 4 (C) 3 (D) 2 (E) 1

可使弱酸 HA 產生的酸性水溶液之 pH 上升的動作: I、II、V

D 75. What is the point group of triphenylphosphine?

(A) D_{3d} (B) D_3 (C) D_{3h} (D) C_3 (E) C_{3v}

2021-2022 的普化課程並未提及 point group 如何判斷
由於 triphenylphosphine 結構上的 3 個苯環會旋轉一個特定角度
因此 triphenylphosphine 只有 C3 旋轉軸，因此其 point group 屬於 C_3



76. Consider a galvanic cell based on the following reactions:

$2\ Au^{3+} + 3\ Mg \rightarrow 2\ Au + 3\ Mg^{2+}$

E

The reduction potentials for Au^{3+} and Mg^{2+}:

$Au^{3+} + 3\ e^- \rightarrow Au,\ \varepsilon^o = 1.5\ V$

$Mg^{2+} + 2\ e^- \rightarrow Mg,\ \varepsilon^o = -2.37\ V$

What is the value of $\Delta G°$?

(A) -84 kJ (B) -373 kJ (C) -746 kJ (D) -1120 kJ (E) -2240 kJ

$\Delta G^\circ = -nFE^\circ = -6 \times 96500 \times (1.5 + 2.37) = -2240\ kJ$

77. What type of radioactive process would be expected in the following reaction?

$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa$

B

(A) α particle production (B) β particle production (C) positron production

(D) γ ray production (E) electron capture

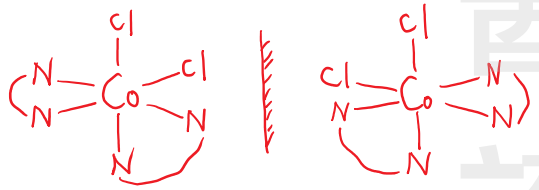
$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e$ (β particle production)

78. Which of the following complexes can exhibit optical isomerism?

C

(A) *cis*-$Co(NH_3)_4Cl_2$ (B) *trans*-$Co(en)_2Br_2$ (C) *cis*-$Co(en)_2Cl_2$

(D) $Co(NH_3)_3Cl_3$ (E) None of the above.



chiral chiral

Cis-$Co(en)_2Cl_2$ 屬於鏡像無法重疊的 chiral 分子

具有光學異構物

79. Which one of the following is paramagnetic?

D

(A) $Zn(H_2O)_6^{2+}$ (B) $Co(NH_3)_6^{3+}$ (C) $Cu(CN)_3^{2-}$ (D) $Mn(CN)_6^{2-}$ (E) $Fe(SCN)_6^{2+}$

$Mn(CN)_6^{2-}$ 的中心金屬為 d^3，必定為順磁

80. A formula of a certain compound is $[M(NH_3)_5Cl]Cl_2$, where the M is a type of metal. The metal ion has 24 electrons in this complex. Determine the identity of the metal.

C

(A) Mn (B) Fe (C) Co (D) Ni (E) Cu

$[M(NH_3)_5Cl]Cl_2$ 的中心金屬氧化數為 +3

M^{+3} 含有 24 個電子，則 M^0 含有 27 個電子 → M = Co

81. Two well-known complex ions containing Ni are $[Ni(H_2O)_6]^{2+}$, which is green, and $[Ni(en)_3]^{2+}$, which is purple. Which one of the following statements is ***true***?

A

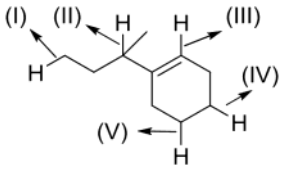
(A) The crystal field splitting energy (Δ) is greater for $[Ni(en)_3]^{2+}$ than for $[Ni(H_2O)_6]^{2+}$.
(B) $[Ni(en)_3]^{2+}$ absorbs energy in the red region of the spectrum.
(C) Both complex ions are diamagnetic.
(D) $[Ni(H_2O)_6]^{2+}$ transmits light with wavelengths of approximately 650–700 nm.
(E) The green complex absorbs green light.

(A)正確
(B)錯誤，$[Ni(en)_3]^{2+}$ 展現紫色應吸收 yellow region 才對
(C)錯誤，兩個 complex 都含有未成對電子，都屬於順磁性
(D)錯誤，$[Ni(H_2O)_6]^{2+}$ 展現綠色應吸收 red region (約650-700 nm)而非穿透
(E)錯誤，green complex 吸收 red light

---

82. Which of the labeled C-H bond is the weakest?

B



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

II 號位置屬於 3級 allylic 位置，鍵能特別弱

---

83. Which of the following alkenes generates the greatest heat upon hydrogenation?

B

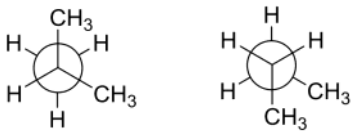
(A) 1,3-pentadine (B) 1,4-pentadiene (C) 1,3-butadiene
(D) *cis*-2-pentene (E) *trans*-2-pentene

1,4-pentadiene 結構上含有 2 組非共軛的 C=C，氫化(hydrogenation)放熱最多

---

84. What is the structural relationship of the following two compounds?

D



(A) not isomers (B) conformational isomers
(C) *cis-trans* isomers (D) structural isomers
(E) both conformational isomers and structural isomers

兩結構屬於分子式相同但 connectivity 不同的結構異構物

85. A tetracyclic compound, aldrin ($C_{12}H_8Cl_6$), was used as an insecticide. How many double bonds are presented in aldrin?

B

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

不飽和度：$\frac{[(12\times2+2)-6]-8}{2}=6$

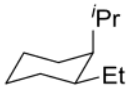
由題目敘述可知 aldrin 為 tetracyclic

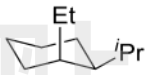
因此 double bond 數量為：$6-4=2$

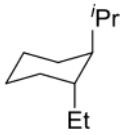
---

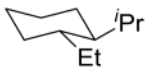
86. Which of following structures presents the most stable conformation of *cis*-1-ethyl-2-isopropylcyclohexane?

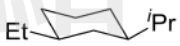
B

(A) 

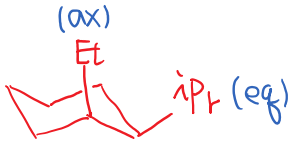
(B) 

(C) 

(D) 

(E) 

cis-1,2雙取代環己烷最穩定的 chair 構型通常優先將立體障礙較大的取代基放在 equatorial 方向



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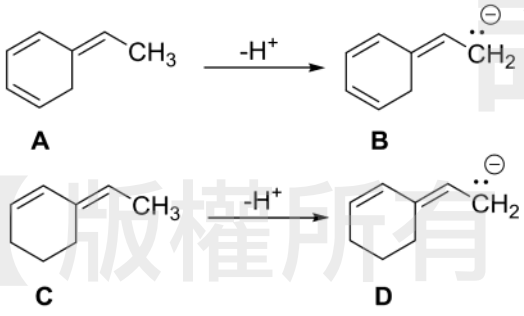
87. Determine the most acidic compound shown below.

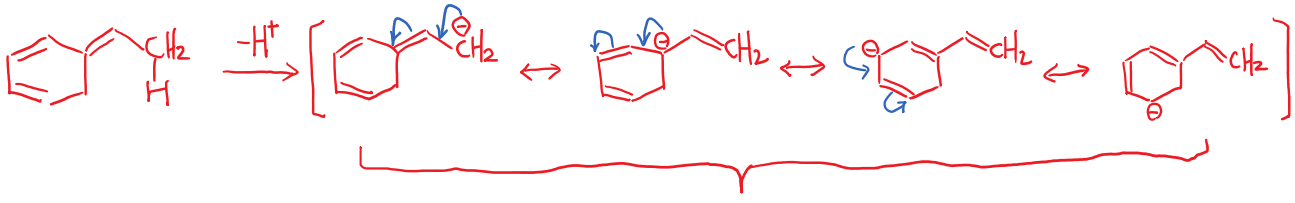
A



(A) A (B) B (C) C (D) D

(E) There is not enough information to determine the acidic order.

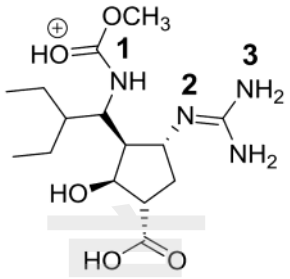
cpd A 解離 H^+ 後可產生最穩定的陰離子，因此 cpd A 的酸性最高



負電荷最分散，穩定度高

88. Peramivir has shown to be effective against the influenza B virus. Rank following nitrogen atoms in the order from the strongest base to the weakest base.

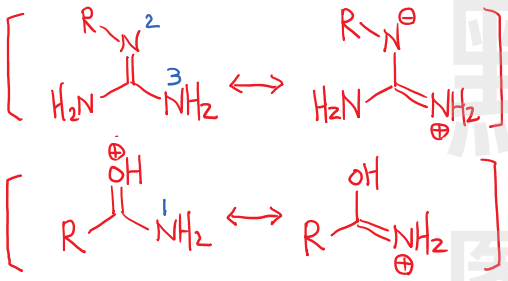
C



(A) 1 > 3 > 2 (B) 2 > 1 > 3 (C) 2 > 3 > 1 (D) 3 > 2 > 1 (E) 3 > 1 = 2

結構上 nitrogen 的鹼性大小: 2 > 3 > 1

原因:



2號位置nitrogen有負電累積增加其鹼性

3號位置nitrogen有正電累積降低其鹼性

1號位置nitrogen的電子更容易提供給帶正電的C=O

鹼性甚至比3號位置更低

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89. Arrange the following arenes in the decreasing reactivity toward HNO_3/H_2SO_4.

(a) PhH (b) PhCl (c) $PhCO_2H$ (d) $PhCH_3$

C

(A) (c) > (d) > (b) > (a) (B) (a) > (b) > (d) > (c) (C) (d) > (a) > (b) > (c)

(D) (d) > (b) > (a) > (c) (E) (a) > (b) > (c) > (d)

取代基對苯環的推電子能力: $CH_3 > H > Cl \gg CO_2H$

对 HNO_3/H_2SO_4 進行 SEAr 的活性：(d) > (a) > (b) > (c)

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90. Which compound exhibits only two signals in its ^1H NMR spectrum, a triplet and a quintet?

A

(A) $BrCH_2CH_2CH_2Br$ (B) $BrCH_2CH_2CH_2Cl$ (C) $(CH_3)_2CHCH(CH_3)_2$

(D) $CH_3CH_2CH_2CH_3$ (E) $(CH_3)_2CHOCH(CH_3)_2$