國立中興大學 112 學年度學士後醫學系招生考試試題

科目：化學　　系所：學士後醫學系甲、乙組

本科目不可以使用計算機　　本科目試題共 10 頁

選擇題(單選)每題兩分共 50 題, 答錯倒扣一分:

1. Which of the following choices represent(s) a pair of resonance forms?

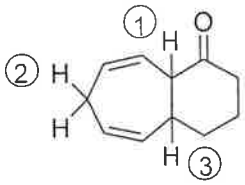
(a) $CH_3CH_2-\overset{\overset{:O:}{\|}}{C}-CH_3$, $CH_3CH=\overset{\overset{:OH}{|}}{C}-CH_3$

(b) $CH_3\overset{\oplus}{C}H-\ddot{O}CH_3$, $CH_3CH=\overset{\oplus}{O}CH_3$

(c) $H_3C\diagdown\ \diagup CH_3\ C=C=\ddot{N}^{\ominus}$, $\ominus:\overset{CH_3}{\underset{CH_3}{\overset{|}{\underset{|}{C}}}}-C\equiv N:$

(A) both (a) and (b)
(B) both (b) and (c)
(C) both (a) and (c)
(D) All of the above

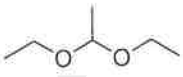
2. Which sequence correctly ranks the following protons in order of increasing acidity?

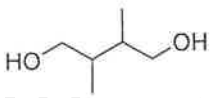


(A) 1<2<3 (B) 2<3<1 (C) 3<1<2 (D) 3<2<1 (E) 2<1<3

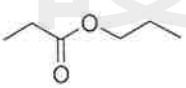
3. Which of the following statements about π molecular orbitals is/are correct?
(A) π molecular orbitals are cylindrically symmetric.
(B) Most of the electron density in a π molecular orbital is centered above and below the internuclear axis.
(C) When two atoms are connected by a double bond, both of these bonds are π bonds.
(D) Both statements B and C are correct.
(E) Statements A, B, and C are all correct.

4. Which of the following compounds is not a constitutional isomer of a compound with an empirical formula C_3H_7O and a formula mass of 118.164?

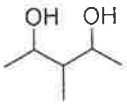

(A)



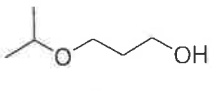
(B)



(C)

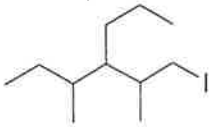


(D)



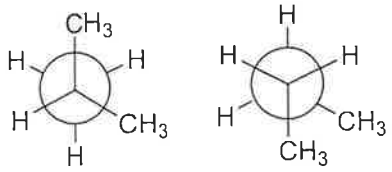
(E)

5. Identify the correct IUPAC name for the following structure.



(A) 3-*s*-Butyl-1-iodo-2-methylhexane
(B) 1-Iodo-2,4-dimethyl-3-propylhexane
(C) 4-(2-Iodo-1-methylethyl)-3-methylheptane
(D) 2,4-Dimethyl-1-iodo-3-propylhexane.

6. The structures below are _____.



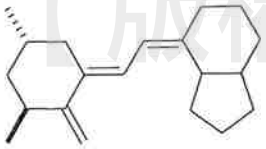
(A) not isomers
(B) conformation isomers
(C) structural isomers
(D) cis-trans isomers
(E) both B and D.

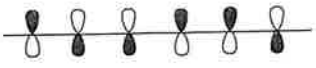
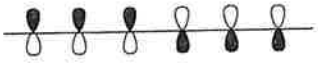
7. When pyridine is treated with a mixture of nitric and sulfuric acids, the major product is _____.
(A) 2-nitropyridine
(B) 3-nitropyridine
(C) 4-nitropyridine
(D) both A and C

8. Which sequence of steps below describes the best synthesis of 5-oxohexanoic acid starting with 1-methylcyclopentan-1-o1?
(A) 1. Conc. $KMnO_4$; 2. Dry gaseous HBr; 3. Mg/ether; 4. CO_2
(B) 1. Conc. $KMnO_4$; 2. CH_3MgBr/ether; 3. H_3O^+
(C) 1. H_2SO_4 and heat; 2. O_3; 3. $(CH_3)_2S$
(D) 1. H_2SO_4 and heat; 2. Conc. $KMnO_4$; 3. $LiAlH_4$; 4. H_3O^+
(E) 1. H_2SO_4 and heat; 2. Conc. $KMnO_4$;

9. What compound is produced when cyclohexene is treated with concentrated $KMnO_4$?
(A) adipic acid
(B) benzoic acid
(C) succinic acid
(D) cyclohexacarboxylic acid
(E) caproic acid

10. Which of the following represents the highest occupied molecular orbital for the conjugated pi system in the structure below?



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

11. What is the major organic product which results when cyclohexene is irradiated in the presence of *N*-bromosuccinimide?
(A) 1-bromocyclohexene
(B) 2-bromocyclohexene

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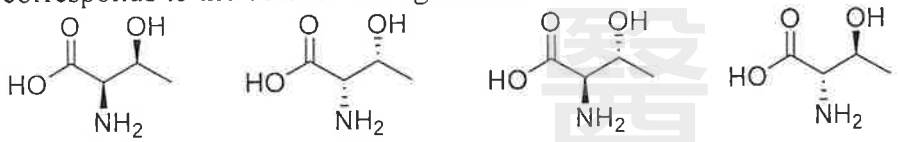
(C) 1,2-dibromocyclohexane
(D) 3-bromocyclohexene
(E) 4-bromocyclohexene

12. Which of the following would not have a C-H stretch at about 3050 cm^{-1}?
(A) 1-pentene
(B) 2-pentene
(C) 2,3-dimethyl-2-pentene
(D) 2-methyl-2-pentene
(E) 2,4-dimethyl-2-pentene

13. What compound has a significant *m/z* 70 in its mass spectrum?
(A) 2-butanol
(B) diethyl ether
(C) (*E*)-2-pentene
(D) 1-pentanol
(E) octane

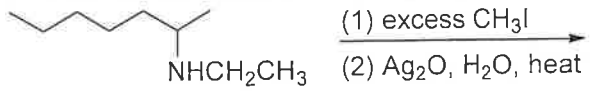
14. The stereochemical configuration of *D*-Threonine is (2*R*, 3*S*). Which of the following structures corresponds to the correct configuration?

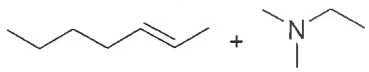
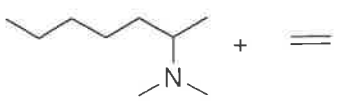


(A)　(B)　(C)　(D)

15. Which series of reactions described below, if any, will result in the formation of 2-methylpentan-3-one starting with 1-propanol?
(A) 1. $(CH_3)_2CHMgBr$; 2. dilute H_3O^+; 3. PCC.
(B) 1. PCC; 2. $(CH_3)_2CHLi$; 3. dilute H_3O^+; 4. $Na_2Cr_2O_7/H_2SO_4$.
(C) 1. $Na_2Cr_2O_7/H_2SO_4$; 2. $2(CH_3)_2CHMgBr$; 3. dilute H_3O^+; 4. $LiAlH_4$.
(D) 1. $Na_2Cr_2O_7/H_2SO_4$; 2. $SOCl_2$; 3. $2(CH_3)_2CHMgBr$; 4. H_3O^+.
(E) none of the above

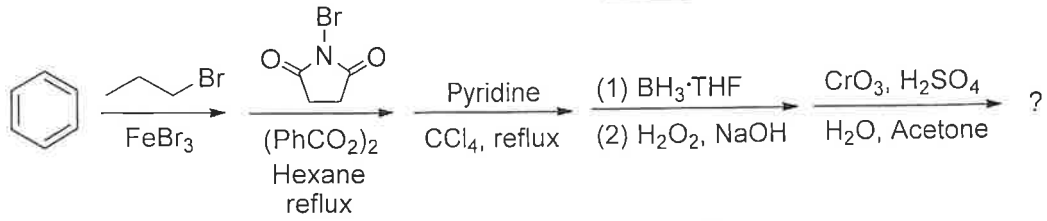
16. Provide the structure of the major product in the reaction below.

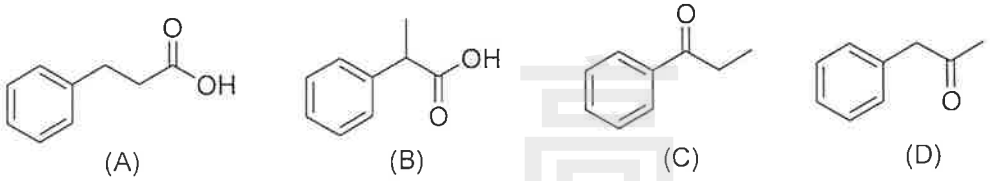


(A) 
(B) 
(C) 
(D) both A and B

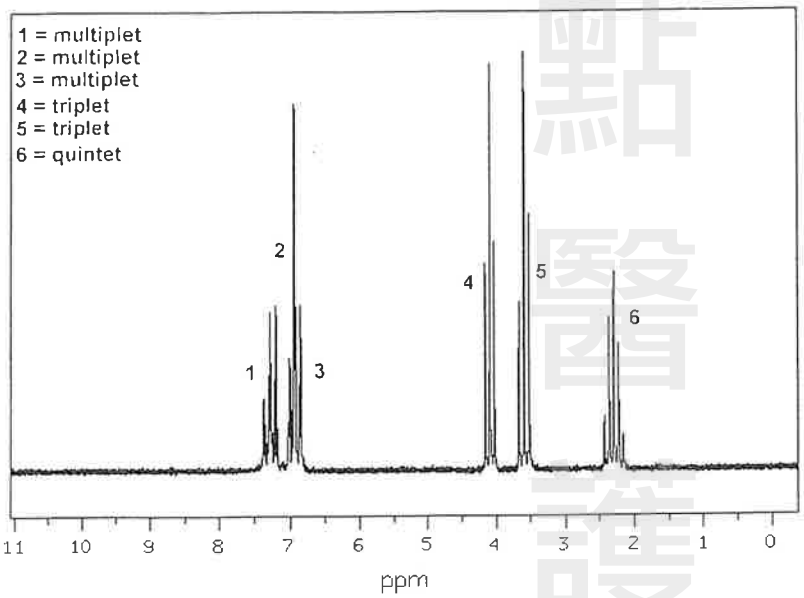
17. Provide the final product of the sequence of steps below?

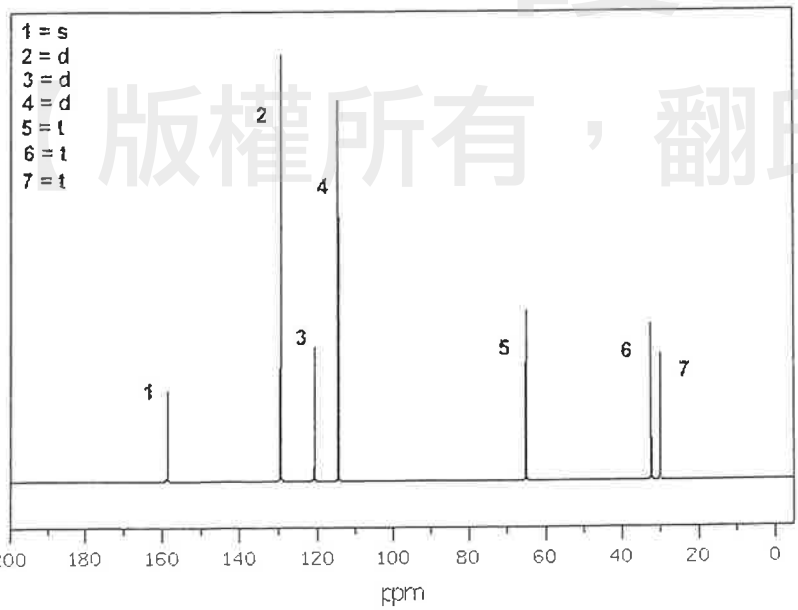
背面有題，請繼續作答。



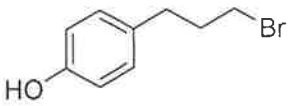


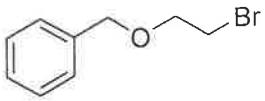
18. Which of the structures shown below is consistent with the C-13 NMR (off resonance splitting for each peak is shown as a table within the figure) and H-NMR spectra? (formula = $C_9H_{11}OBr$)

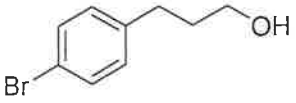


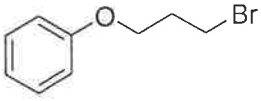


(A) 

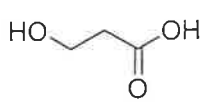
(B) 

(C) 

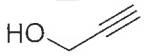
(D) 

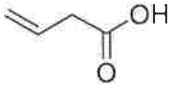
(E) 

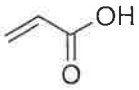
19. Provide the final product of the sequence of steps below?

(A) 

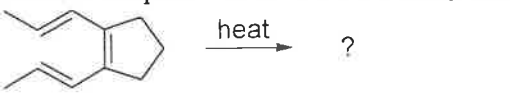
(B) 

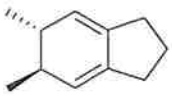
(C) 

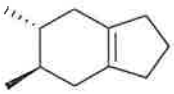
(D) 

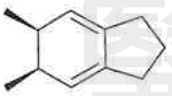
(E) 

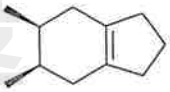
20. Predict the product of the following reaction, including stereochemistry.



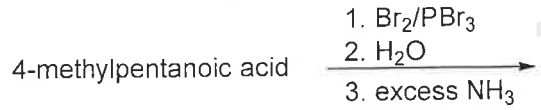
(A) 

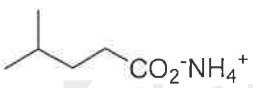
(B) 

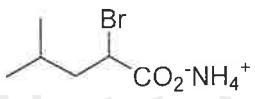
(C) 

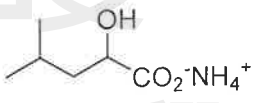
(D) 

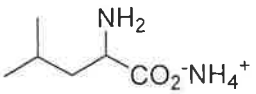
21. Provide the final product of the sequence of steps below?



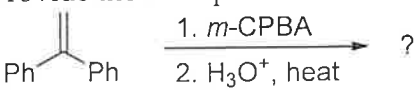
(A) 

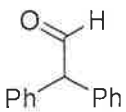
(B) 

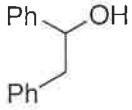
(C) 

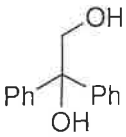
(D) 

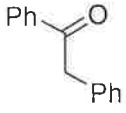
22. Provide the final product of the sequence of steps below?



(A) 

(B) 

(C) 

(D) 

23. Predict the major product of the following reaction?

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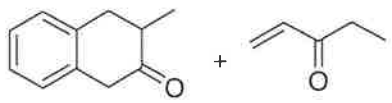
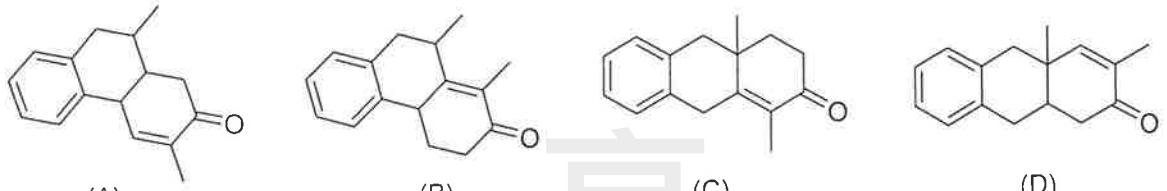
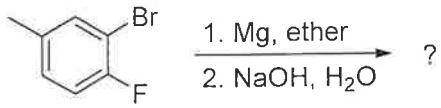
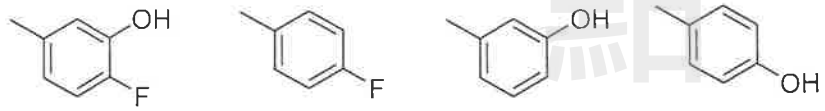




(A)　(B)　(C)　(D)

24. Predict the products of the following reaction.

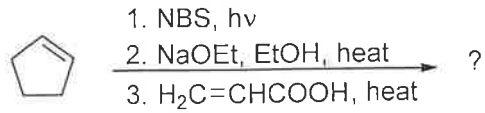


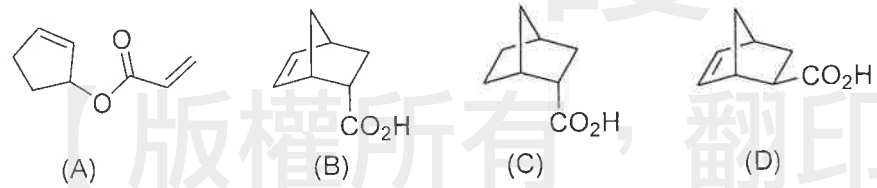


(a)　(b)　(c)　(d)

(A) both (a) and (b)
(B) both (b) and (c)
(C) both (c) and (d)
(D) both (b) and (d)

25. Predict the major product of the following reaction?





(A)　(B)　(C)　(D)

26. What is the point group of BIClF (chlorofluoroiodoborane)?
(A) C_{2v} (B) C_{3v} (C) D_{3h} (D) C_s (E) C_i

27. Consider the calculation:
$52.00 + 1.001 - 13.1 + 1.3129 =$
Which of the following is the correct answer for the number of significant figures for this question?
(A) 41 (B) 41.2 (C) 41.21 (D) 41.214 (E) 41.2139

28. Which of the following statements about thermodynamics is/are correct?
I. The first law of thermodynamics is the Law of Conservation of Energy

國立中興大學 112 學年度學士後醫學系招生考試試題

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II. A perfect crystalline structure, will have no entropy (S) at 0 °C.
III. The Second Law of Thermodynamics states that all spontaneous changes keep the conservation in the entropy of the universe.
IV. The first law of thermodynamics defines the internal energy (E) as equal to the difference between the heat transfer (Q) into a system and the work (W) done by the system.
(A) I, II (B) I, III (C) I, II, III (D) I, IV (E) I, II, III, IV

29. Consider the structure of bicarbonate ion CO_3^{-2}. Which of the following statements is false?
(A) All the charges of three O ions are equivalent.
(B) One C-O bond is shorter than the other two at room temperature.
(C) The carbon atom possess three sp^2 hybridized orbitals.
(D) The geometric shape is trigonal planar.
(E) More than one Lewis structure is allowed.

30. The naming of chemical compounds, including ions and molecules is important in chemistry and other scientific fields. Indicate which one of the compound names is incorrect.
(A) K_2O is potassium oxide (B) $Mn(OH)_2$ is magnesium(II) hydroxide (C) CO is carbon monoxide
(D) sulfur hexafluoride is SF_6 (E) NH_3 is ammonia

31. Calcium is a metal, and sulfur is a nonmetal. They are in a different family of the periodic table. When they become ions, Ca^{2+} and S^{2-}, which characteristic of the following would be the correct relation between Ca^{2+} and S^{2-} ions?
(A) isomeric (B) isotopic (C) isoelectronic (D) isochromatic (E) isobaric

32. The van't Hoff factor (i) express the effective concentration of particles for a solute. In comparison with NaCl aqueous solution, what properties of the solution of $MgSO_4$ may be lower than those of $NaCl_{(aq)}$ as these two solutions are identical in concentration?
(A) boiling point, osmotic pressure
(B) freezing point, osmotic pressure
(C) osmotic pressure
(D) vapor pressure, osmotic pressure
(E) boiling point, freezing point

33. The orbital wavefunction for the state (n =3, l = 1, and m_l = 0) of the hydrogen atom, is expressed as

$$\Psi_{3p_z} = \frac{\sqrt{2}}{81\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{\frac{3}{2}}(6\sigma - \sigma^2)e^{-\sigma/3}cos\vartheta$$

Where $\sigma = r/a_0$ and a_0 is the Bohr radius. How many nodal surfaces will appear in the wave function?
(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

34. Redox reaction includes oxidation and reduction simultaneously. Balance the following redox reaction in the basic solution

$$Cr_2O_7^{2-}(aq) + Cl^-(aq) \rightarrow Cr^{3+}(aq) + Cl_2(aq)$$

Indicate how many water molecules will exist in the balanced ionic equation
(A) 14 (B) 7 (C) 12 (D) 6 (E) none

第 7 頁　　背面有題，請繼續作答。

國立中興大學 112 學年度學士後醫學系招生考試試題

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35. How many types of oxidation numbers are for the hydrogen atom in the following compounds? H_2O_2, CH_4, H_2O, $NaBH_4$, H_2, HNO_3, CaH_2, and NH_3
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

36. Which statement of the following about hydrogen bonding is *not true*?
(A)Hydrogen bonds can be intermolecular (occurring between separate molecules) or intramolecular (occurring among parts of the same molecule)
(B) Hydrogen atom in molecules is attached by a highly electronegative atom (N, O , F)
(C) An unpaired electron at least resides on the highly electronegative atom (N, O, F)
(D) Due to the higher boiling point of H_2O than HF, a H-bond between two H_2O molecules is stronger than a H-bond between two H-F molecules.
(E) The interactive way of the hydrogen bond is the same as that of dipole-dipole intermolecular interaction

37. According to the solubility rules, how many of the following spices should be *soluble* in water?
Hg_2Cl_2, Ag_2S, Ag_2CO_3, $PbSO_4$, Na_2S
(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

38. Construct a table of Crystal Field Stabilization Energy (CFSE) for all d^n electronic configurations in tetrahedral complexes under a strong field, Which d^n configuration could be diamagnetic?
(A) d^1 (B) d^2 (C) d^4 (D) d^6 (E) d^8

39. Reactions of a series of substituted pyridines with BF_3 shows the order of Lewis basicity: Pyridine > 2-methylpyridine > 2,6-dimethylpyridine > 2-t-butylpyridine.Which of the following effects induces this order?
(A) I-strain (B) B-strain (C) F-strain (D) inductive effect (E) leveling effect

40. Consider the following reactions, which one of the following will have the smallest equilibrium constant at 298 K?
(A) $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$ $\Delta G° = -131.1$ kJ
(B) $2Hg(g) + O_2(g) \rightarrow 2HgO(s)$ $\Delta G° = -180.8$ kJ
(C) $3O_2(g) \rightarrow 2O_3(g)$ $\Delta G° = +326$ kJ
(D) $2H_2O(aq) \rightarrow 2H_2(s) + O_2(g)$ $\Delta G° = +475.4$ kJ
(E) More information is needed to determine.

41. Regarding the "Quantum Mechanics and Atomic Structure", which one of the following statements is *incorrect*?
(A) The discovery of "Blackbody Radiation" paves a foundation for scientists to find the quantization of atomic energy.
(B) The "Aufbau principle" states that the proper way of placement of electrons in atomic orbitals is from the lowest energy level up and shall also obey Hund's rule.
(C) The "Zero Point Energy" states that the energy level is lowest in this state of the atomic orbitals. However, it is not equal to zero.
(D) The "Heisenberg Indeterminacy Principle: states that one can't make a completely accurate measurement of both the position (x) and its moment (mv) of a particle.

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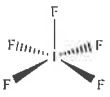
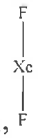
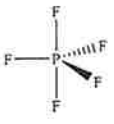
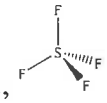
(E) "Hund's rule" implies that while electrons place into degenerated orbitals, they will pair each other first.

42. Which one of the following statements is *incorrect* for "Kinetics"?
(A) The orders for the reactions in Kinetics have nothing to do with the coefficient of the reaction.
(B) It is possible that a non-integer reaction order can be found in a reaction.
(C) The derivation of the first-order reaction leads to $C = C_0e^{-kt}$. (C_0: initial concentration; C: concentration at moment t; t: reaction time)
(D) A rather useful concept of "half-life ($t_{1/2}$)" can be derived from the concept of the zero-order reaction.
(E) The relative stabilities of the reactant and product have nothing to do with the reaction rate.

43. Pick the *correct* molecular structure(s) as predicted by the VSEPR theory?

(I) IF_5,  (II) XeF_2,  (III) ClF_3,  (IV) PF_5,  (V) SF_4, 

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

44. Pick the *correct* one from the following statements about the electrochemical cell described below?
$Sn \mid Sn^{2+}(aq) \parallel Li^{+}(aq) \mid Li$
$Sn^{2+}(aq) + 2e^{-} \rightarrow Sn(s)$; $E° = -0.14$ V
$Li^{+}(aq) + e^{-} \rightarrow Li(s)$; $E° = -3.04$ V
(A) The cell reaction is spontaneous with a standard cell potential of 3.18 V.
(B) The cell reaction is spontaneous with a standard cell potential of -2.90 V.
(C) The cell reaction is nonspontaneous with a standard cell potential of -2.90 V.
(D) The cell reaction is nonspontaneous with a standard cell potential of -3.18 V.
(E) The cell is at equilibrium.

45. When pure water (pH = 7 at 25 °C) is heated, it will induce:
(A) $[H^+] > [OH^-]$
(B) The water is not neutral.
(C) pH is still 7
(D) $[H^+] < [OH^-]$
(E) None of these.

46. Which of the following statements about the ^1H NMR (Nuclear Magnetic Resonance) experiment is *incorrect*?
(A) The energy difference between the two spin states ($m_I = +1/2$ and $m_I = -1/2$) depends on the strength of the magnetic field.
(B) When energy absorption takes place, the electrons are excited by the electromagnetic radiation to obtain the NMR signal.
(C) When aligned with the magnetic field, the energy of a proton with spin of $m_I = +1/2$ is lower than that with $m_I = -1/2$ when aligned against it.
(D) The relative population of the upper spin state, N_{upper}, and of the lower spin state, N_{lower}, is given by the Boltzmann equation ($N_{upper} / N_{lower} = e^{-\Delta E/kT}$).

第 9 頁　　背面有題，請繼續作答。

國立中興大學 112 學年度學士後醫學系招生考試試題

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(E) The energy needed to flip the spin of a proton is within the radio frequency range of the electromagnetic spectrum.

47. Which of the following compounds *does not* exhibit an optical isomer? (en: $NH_2CH_2CH_2NH_2$)
(A) *cis*-$[Co(en)_2(Cl)_2]^+$ (B) $[Co(en)_3]^{3+}$ (C) *cis*-$[OsCl_2(CO)_4]$ (D) isobutanol (E) *trans*-$[Co(en)_2Cl_2]^+$

48. Which of the following statements is *incorrect* regarding molecules of an ideal gas?
(A) Molecules of an ideal gas undergo many collisions with each other and the container walls.
(B) The molecules of an ideal gas are relatively far apart.
(C) Molecules of greater mass have a lower average speed than that of less mass at the same temperature.
(D) The average speed of molecules from samples of different "ideal" gases is the same at the same temperature.
(E) All molecules of an ideal gas have the same average kinetic energy at a constant temperature.

49. The proposed mechanism for the reaction of $H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$ is as follows.:

(1) $H_2O_2 + I^- \rightarrow HOI + OH^-$ *Slow*

(2) $OH^- + H^+ \rightarrow H_2O$ *Fast*

(3) $HOI + H^+ + I^- \rightarrow I_2 + H_2O$ *Fast*

Based on the proposed mechanism, determine the order of H^+ in this reaction by identifying the rate law that is consistent with it.
(A) 4 (B) 3 (C) 2 (D) 1 (E) 0

50. Determine the pH of a buffered solution containing 0.15 M NH_3 ($K_b = 1.8 \times 10^{-5}$) and 0.35 M NH_4Cl.
(A) 4.7 (B) 5.1 (C) 6.3 (D) 7.2 (E) 9.1

科目：化學

題號	答案	題號	答案	題號	答案	題號	答案	題號	答案	題號	答案	題號	答案
1.	B	16.	C	31.	C	46.	B	61.		76.		91.	
2.	D	17.	B	32.	A	47.	C	62.		77.		92.	
3.	B	18.	E	33.	D	48.	D	63.		78.		93.	
4.	C	19.	E	34.	B	49.	E	64.		79.		94.	
5.	C	20.	C	35.	C	50.	E	65.		80.		95.	
6.	C	21.	D	36.	D	51.		66.		81.		96.	
7.	B	22.	A	37.	B	52.		67.		82.		97.	
8.	E	23.	B	38.	C	53.		68.		83.		98.	
9.	A	24.	C	39.	C	54.		69.		84.		99.	
10.	A	25.	B	40.	D	55.		70.		85.		100.	
11.	D	26.	D	41.	E	56.		71.		86.			
12.	C	27.	B	42.	D	57.		72.		87.			
13.	D	28.	D	43.	D	58.		73.		88.			
14.	A	29.	B	44.	C	59.		74.		89.			
15.	B	30.	B	45.	E	60.		75.		90.			

國立中興大學 112 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	疑義答覆	釋疑結果
化學	33	根據題意上說明，正確答案應為(C)而非(D)。	答案更正為(C)
	47	根據題意上說明，正確答案應為(C)或(D)或(E)，三者任一皆可給分。	答案更改為(C)或(D)或(E)

化　學

梁傑(梁家榮)老師提供

B

1. Which of the following choices represent(s) a pair of resonance forms?

(a) $CH_3CH_2-\overset{\displaystyle :O:}{\overset{\|}{C}}-CH_3$, $CH_3CH=\overset{\displaystyle :OH}{\overset{|}{C}}-CH_3$

(b) $CH_3\overset{\oplus}{C}H-\ddot{O}CH_3$, $CH_3CH=\overset{\oplus}{O}CH_3$

(c) $H_3C\diagdown\!\!\diagup C=C=\ddot{N}:^{\ominus}$, $:\!\overset{\ominus}{C}(CH_3)_2-C\equiv N:$

(A) both (a) and (b)
(B) both (b) and (c)
(C) both (a) and (c)
(D) All of the above

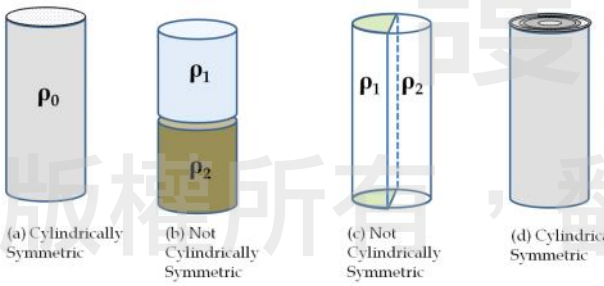
(a)屬於互變異構的平衡(原子的連接方式有改變)，並非 resonance forms
(b)、(c)只有 lone pair 或 π 電子移動，原子間連接方式並未改變，屬於 resonance forms

(b) $CH_3\overset{\oplus}{C}H-\ddot{O}CH_3 \longleftrightarrow CH_3CH=\overset{\oplus}{O}CH_3$

(c) $H_3C\diagdown\!\!\diagup C=C=\ddot{N}:^{\ominus} \longleftrightarrow :\!\overset{\ominus}{C}(CH_3)_2-C\equiv N:$

B

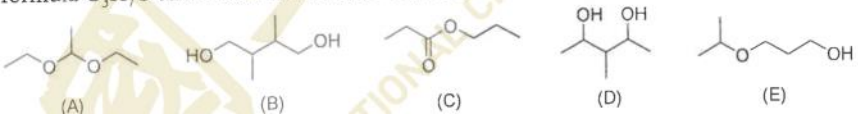
3. Which of the following statements about π molecular orbitals is/are correct?
(A) π molecular orbitals are cylindrically symmetric.
(B) Most of the electron density in a π molecular orbital is centered above and below the internuclear axis.
(C) When two atoms are connected by a double bond, both of these bonds are π bonds.
(D) Both statements B and C are correct.
(E) Statements A, B, and C are all correct.



(A)錯誤，π -bond 並非圓柱對稱(cylindrically symmetric)
(B)正確，π 電子出現在核間軸的上方或下方，軸上是節點
(C)錯誤，double bond 由 1 組 σ -bond 和 1 組 π -bond 構成

C

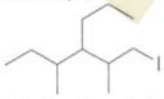
4. Which of the following compounds is not a constitutional isomer of a compound with an empirical formula C_3H_7O and a formula mass of 118.164?



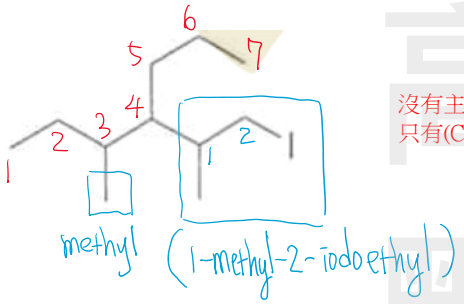
(C)選項有 1 組 C=O，一看就知道不飽和度與 (A)、(B)、(D)、(E) 不同

C

5. Identify the correct IUPAC name for the following structure.



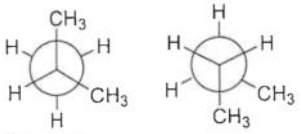
(A) 3-*s*-Butyl-1-iodo-2-methylhexane
(B) 1-Iodo-2,4-dimethyl-3-propylhexane
(C) 4-(2-Iodo-1-methylethyl)-3-methylheptane
(D) 2,4-Dimethyl-1-iodo-3-propylhexane.



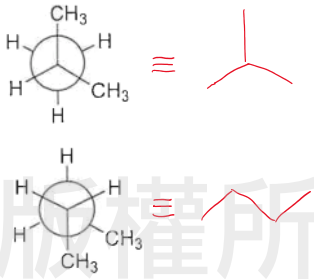
沒有主官能基，因此找 7 碳的當作主鏈
只有(C)選項有 heptane 的主鏈

C

6. The structures below are _____.



(A) not isomers
(B) conformation isomers
(C) structural isomers
(D) cis-trans isomers
(E) both B and D.



分子式相同但組成原子之間連接順序不同
屬於結構異構物(structural isomer)

B

27. Consider the calculation:
52.00 + 1.001 − 13.1 + 1.3129 =
Which of the following is the correct answer for the number of significant figures for this question?
(A) 41 (B) 41.2 (C) 41.21 (D) 41.214 (E) 41.2139

52.00 + 1.001 = 53.001 ⇒ 53.001 − 13.1 = 39.901 ⇒ 39.901 + 1.3129 = 41.2139 四捨五入 ⇒ 41.2

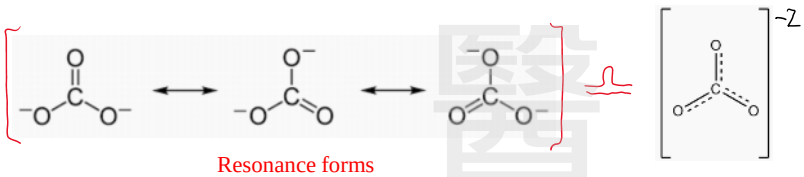
D

28. Which of the following statements about thermodynamics is/are correct?
I. The first law of thermodynamics is the Law of Conservation of Energy
II. A perfect crystalline structure, will have no entropy (S) at 0 °C.
III. The Second Law of Thermodynamics states that all spontaneous changes keep the conservation in the entropy of the universe.
IV. The first law of thermodynamics defines the internal energy (E) as equal to the difference between the heat transfer (Q) into a system and the work (W) done by the system.
(A) I, II (B) I, III (C) I, II, III (D) I, IV (E) I, II, III, IV

II錯誤，0 K 的完美單晶其熵為零，而非 0℃
III錯誤，使 $\Delta S_{univ} > 0$ 才是自發過程

B

29. Consider the structure of bicarbonate ion CO_3^{-2}. Which of the following statements is false?
(A) All the charges of three O ions are equivalent.
(B) One C-O bond is shorter than the other two at room temperature.
(C) The carbon atom possess three sp^2 hybridized orbitals.
(D) The geometric shape is trigonal planar.
(E) More than one Lewis structure is allowed.



Resonance forms

室溫下
所有 C–O bond 都等長

---

b

30. The naming of chemical compounds, including ions and molecules is important in chemistry and other scientific fields. Indicate which one of the compound names is incorrect.
(A) K_2O is potassium oxide (B) $Mn(OH)_2$ is magnesium(II) hydroxide (C) CO is carbon monoxide
(D) sulfur hexafluoride is SF_6 (E) NH_3 is ammonia

(B)錯誤，$Mn(OH)_2$的名稱為 manganese(II) hydroxide 才對

C

31. Calcium is a metal, and sulfur is a nonmetal. They are in a different family of the periodic table. When they become ions, Ca^{2+} and S^{2-}, which characteristic of the following would be the correct relation between Ca^{2+} and S^{2-} ions?
(A) isomeric (B) isotopic (C) isoelectronic (D) isochromatic (E) isobaric

Ca^{2+} 和 S^{2-} 都有 18 個電子，屬於等電子離子(isoelectronic ion)

C

33. The orbital wavefunction for the state (n =3, l = 1, and m_l = 0) of the hydrogen atom, is expressed as

$$\Psi_{3p_z} = \frac{\sqrt{2}}{81\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{\frac{3}{2}}(6\sigma - \sigma^2)e^{-\sigma/3}cos\vartheta$$

Where $\sigma = r/a_0$ and a_0 is the Bohr radius. How many nodal surfaces will appear in the wave function?
(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

3p_z軌域有1个徑向節和1个角向節，總共有2个nodal surface

B

34. Redox reaction includes oxidation and reduction simultaneously. Balance the following redox reaction in the basic solution

$Cr_2O_7^{2-}(aq) + Cl^-(aq) \rightarrow Cr^{3+}(aq) + Cl_2(aq)$

Indicate how many water molecules will exist in the balanced ionic equation
(A) 14 (B) 7 (C) 12 (D) 6 (E) none

平衡的反應方程式： $7H_2O + Cr_2O_7^{2-} + 6Cl^- \longrightarrow 2Cr^{+3} + 3Cl_2 + 14OH^-$

C

35. How many types of oxidation numbers are for the hydrogen atom in the following compounds?
H_2O_2, CH_4, H_2O, $NaBH_4$, H_2, HNO_3, CaH_2, and NH_3
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

H 的氧化數為 +1： H_2O_2、H_2O、HNO_3、NH_3

H 的氧化數為 0： H_2

H 的氧化數為 −1： CH_4、$NaBH_4$、CaH_2

D

36. Which statement of the following about hydrogen bonding is *not true*?
(A)Hydrogen bonds can be intermolecular (occurring between separate molecules) or intramolecular (occurring among parts of the same molecule)
(B) Hydrogen atom in molecules is attached by a highly electronegative atom (N, O , F)
(C) An unpaired electron at least resides on the highly electronegative atom (N, O, F)
(D) Due to the higher boiling point of H_2O than HF, a H-bond between two H_2O molecules is stronger than a H-bond between two H-F molecules.
(E) The interactive way of the hydrogen bond is the same as that of dipole-dipole intermolecular interaction

(D)選項錯誤
H_2O 沸點卻比 HF 高，這是因為 H_2O 氫鍵數量較多所造成的結果
並非 H_2O 的 H-bonding 比 HF 強

B

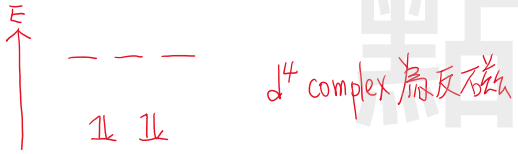
37. According to the solubility rules, how many of the following spices should be *soluble* in water?
Hg_2Cl_2, Ag_2S, Ag_2CO_3, $PbSO_4$, Na_2S
(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

不溶於水：Hg_2Cl_2、Ag_2S、Ag_2CO_3、$PbSO_4$
可溶於水：Na_2S

C

38. Construct a table of Crystal Field Stabilization Energy (CFSE) for all d^n electronic configurations in tetrahedral complexes under a strong field, Which d^n configuration could be diamagnetic?
(A) d^1 (B) d^2 (C) d^4 (D) d^6 (E) d^8

若為 Td 結構的強場 complex (事實上很少出現此情況)
但若按照題目的規定：



D

40. Consider the following reactions, which one of the following will have the smallest equilibrium constant at 298 K?
(A) $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$ $\Delta G° = -131.1$ kJ
(B) $2Hg(g) + O_2(g) \rightarrow 2HgO(s)$ $\Delta G° = -180.8$ kJ
(C) $3O_2(g) \rightarrow 2O_3(g)$ $\Delta G° = +326$ kJ
(D) $2H_2O(aq) \rightarrow 2H_2(s) + O_2(g)$ $\Delta G° = +475.4$ kJ
(E) More information is needed to determine.

$\Delta G° = -RT\ln K_{eq} \Rightarrow \Delta G° \gg 0$ 則 $K_{eq} \ll 1$

E

41. Regarding the "Quantum Mechanics and Atomic Structure", which one of the following statements is *incorrect*?
(A) The discovery of "Blackbody Radiation" paves a foundation for scientists to find the quantization of atomic energy.
(B) The "Aufbau principle" states that the proper way of placement of electrons in atomic orbitals is from the lowest energy level up and shall also obey Hund's rule.
(C) The "Zero Point Energy" states that the energy level is lowest in this state of the atomic orbitals. However, it is not equal to zero.
(D) The "Heisenberg Indeterminacy Principle: states that one can't make a completely accurate measurement of both the position (x) and its moment (mv) of a particle.
(E) "Hund's rule" implies that while electrons place into degenerated orbitals, they will pair each other first.

(E)選項錯誤，Hund's rule 是電子填入等能量的能皆時，應先填半滿後全滿

C

44. Pick the *correct* one from the following statements about the electrochemical cell described below?
Sn | $Sn^{2+}(aq)$ || $Li^{+}(aq)$ | Li
$Sn^{2+}(aq) + 2e^{-} \rightarrow Sn(s)$; $E° = -0.14$ V
$Li^{+}(aq) + e^{-} \rightarrow Li(s)$; $E° = -3.04$ V
(A) The cell reaction is spontaneous with a standard cell potential of 3.18 V.
(B) The cell reaction is spontaneous with a standard cell potential of -2.90 V.
(C) The cell reaction is nonspontaneous with a standard cell potential of -2.90 V.
(D) The cell reaction is nonspontaneous with a standard cell potential of -3.18 V.
(E) The cell is at equilibrium.

依照題目的 cell diagram：
Sn electrode 為陽極(發生氧化)；Li electrode 為陰極(發生還原)

$E°_{cell} = (+0.14) + (-3.04) = -2.90$ V (non-spontaneous rxn)

E

45. When pure water (pH = 7 at 25 °C) is heated, it will induce:
(A) $[H^+] > [OH^-]$
(B) The water is not neutral.
(C) pH is still 7
(D) $[H^+] < [OH^-]$
(E) None of these.

加熱純水會使 H_2O 解離度變大
$[H^+]$ 和 $[OH^-]$ 一起變多，但 $[H^+]$ 依然等於 $[OH^-]$ ⇒ (A)(B)(D)錯誤

也會造成 pH 下降，pOH 也下降 ⇒ (C)錯誤

D

48. Which of the following statements is *incorrect* regarding molecules of an ideal gas?
(A) Molecules of an ideal gas undergo many collisions with each other and the container walls.
(B) The molecules of an ideal gas are relatively far apart.
(C) Molecules of greater mass have a lower average speed than that of less mass at the same temperature.
(D) The average speed of molecules from samples of different "ideal" gases is the same at the same temperature.
(E) All molecules of an ideal gas have the same average kinetic energy at a constant temperature.

(D)選項錯誤，相同溫度時，不同分子量的氣體之平均速度不同 ⇒ $V_{avg} \propto \sqrt{\frac{T}{MW}}$

(E)選項正確，相同溫度時，不同分子量的氣體之平均動能相同 ⇒ $(KE)_{avg} \propto T$

E

50. Determine the pH of a buffered solution containing 0.15 M NH_3 ($K_b = 1.8 \times 10^{-5}$) and 0.35 M NH_4Cl.
(A) 4.7 (B) 5.1 (C) 6.3 (D) 7.2 (E) 9.1

$$pH = pKa + \log\left(\frac{[A^-]}{[HA]}\right) = 9.25 + \log\left(\frac{0.15}{0.35}\right) = 8.89$$