※注意：請於試卷上「選擇題作答區」依序作答。

Boltzmann constant	1.38×10^{-23} J K^{-1}
Faraday constant	96500 C/mol
Gas constant	8.206×10^{-2} L atm $K^{-1}mol^{-1}$
Avogadro constant	6.02×10^{23} mol^{-1}

Section A：(48%，單選題，每題答對 4 分)

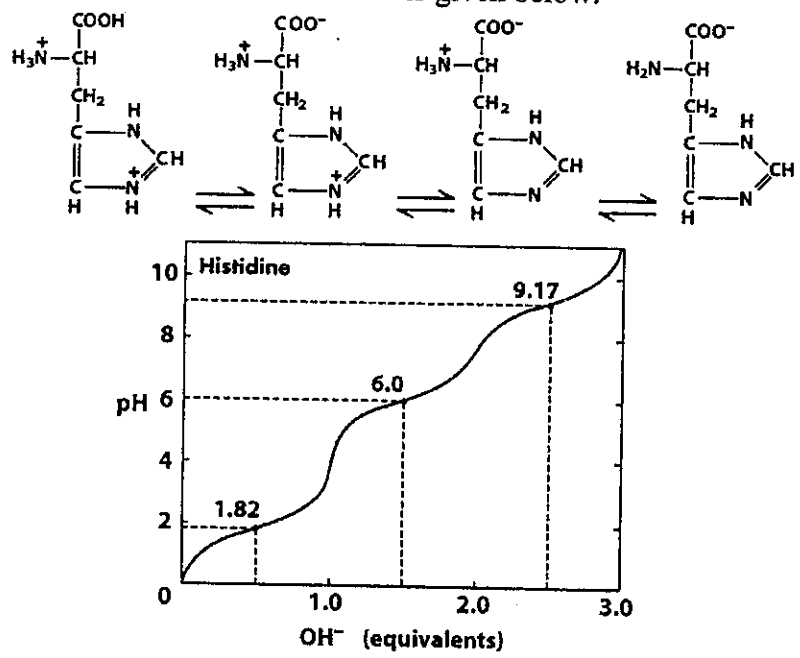
1 Which of the following descriptions of solution is correct?
- A. During the dissolution of NaCl in water, the separation of solvent molecules is the most endothermic process.
- B. In the presence of osmotic pressure, the net diffusion of ions from high concentration region to low concentration region is always spontaneous.
- C. The pH value of a 1.0 M NH_4Cl aqueous solution is higher than that of a 1.5 M NaBr aqueous solution.
- D. The introduction of non-volatile solute to a solvent increases the vapor pressure of the solvent, and therefore the the boiling point of the solute-solvent system will be depressed.
- E. The freezing point of a 1.0 M NaCl aqueous solution is identical to that of a 1.0 M of $MgCl_2$ aqueous solution

2 If there are a total of 327 protein molecules confined in a volume of 8.18×10^{-15} cm^3, what is the concentration of the protein?
- A. 66.4 nM
- B. 66.4 μM
- C. 40.0 nM
- D. 40.0 μM
- E. None of the above

3 Which of the following statements is correct?
- A. Entropy is the definition of disorder in quantum mechanics
- B. At room temperature and under one atmospheric pressure, one mole of H_2O has higher entropy than one mole of argon
- C. States of greater disorder are favored over more ordered states
- D. Enthalpy is defined as the internal energy minus the product of pressure and volume: $H = E - PV$
- E. Arrhenius equation states that the reaction rate constant (k) is linearly proportional to the difference in standard Gibbs free energy (ΔG^0).

見背面

4 The titration curve of histidine is given below:



Which of the following statements is INCORRECT?

A. The pI of histidine is between pH 1.82 and 6.0.

B. Histidine becomes an anion at pH > 12.

C. There are three different pK_a values for histidine.

D. There are three different pK_b values for histidine.

E. Below a pH of 6.0, the histidine is mostly positively charged.

5 For a $[H^+]$ concentration of 0.0200 M, the pH value should read

A. 1.6990 B. 1.699 C. 1.7 D. 1.70 E. −1.7

6 Assume ideal gas behavior, what is the molar mass of a vapor that has a density of 8.864 g/L at 19 °C and 0.873 atm?

A. 1.6×10^1 g/mol

B. 1.58×10^1 g/mol

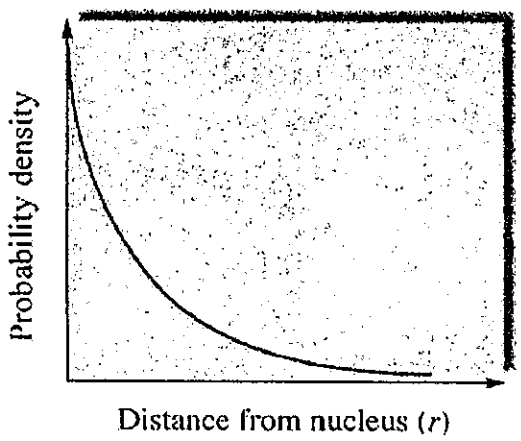
C. 2.43×10^2 g/mol

D. 2.4×10^2 g/mol

E. 2400 g/mol

接次頁

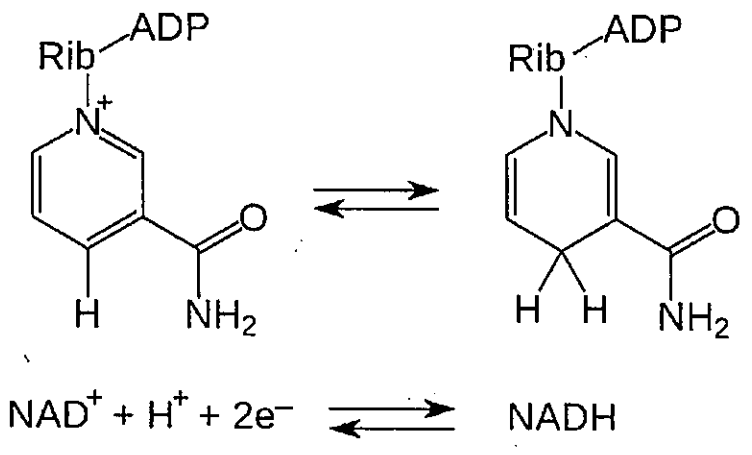
7 Consider the following probability density calculated for an orbital of a hydrogen atom:



Which of the following statements is correct?

A. The probability of finding the electron at the nucleus is highest.
B. The curve corresponds to what we expected for p type orbitals.
C. The curve corresponds to the modulus square of the wavefunction of 1s orbital.
D. The probability of finding the electron residing in the orbital is equal to the area under the curve.
E. None of the above

8 The following figure describes the half-reaction of nicotinamide adenine dinucleotide, where Rib and ADP represent ribose ring and adenosine diphosphate, respectively.



見背面

Which of the following statements is INCORRECT?

A. NAD^+ is an oxidizing agent.
B. For NAD^+, the nitrogen with a formal charge of +1 has a 2p orbital perpendicular to the ring plane.
C. For the six-member ring connected to Rib, electrons are delocalized in NAD^+ but are more localized in NADH.
D. For the six-member ring of NADH, the angle between the two C–H bonds is smaller than 90 degrees.
E. NADH is a reducing agent.

9 Cytochrome, $CyFe^{2+}$, reacts with the air we breathe in to supply energy required to synthesize adenosine triphosphate (ATP). Our body uses ATP as an energy source to drive other reactions. At pH 7.0 the following reduction potentials pertain to the oxidation of $CyFe^{2+}$:

$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l) \qquad E_{red} = +0.60\ V$$
$$CyFe^{3+}(aq) + e^- \rightarrow CyFe^{2+}(aq) \qquad E_{red} = +0.22\ V$$

If the synthesis of 1.00 mol of ATP requires a ΔG of 37.7 kJ, how many moles of ATP are synthesized per mole of O_2?

A. 6.1
B. 3.9
C. 2.9
D. 4.7
E. 8.2

10 Which of the following statements is INCORRECT?

A. In a given atom no two electrons can have the same set of four quantum numbers.
B. There is a fundamental limitation to just how precisely we can know both the location and the momentum of an object at a given time.
C. Electron cannot move around the nucleus in circular orbits.
D. If n is the principal quantum number of a hydrogen atom, the total number of orbitals with $n = 3$ is equal to 9.
E. For a given atom, the 2s and 2p orbitals always have the same energy.

11 According to the kinetic data of the reaction,

$$A + B + C \rightarrow E + F$$

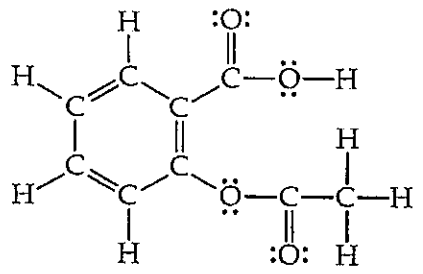
	$[A]_0$	$[B]_0$	$[C]_0$	Rate = $-\Delta[A]/\Delta t$
I	0.100 *M*	5.0×10^{-4} *M*	1.0×10^{-2} *M*	0.137 *M*/sec
II.	0.100 *M*	1.0×10^{-3} *M*	1.0×10^{-2} *M*	0.274 *M*/sec
III.	0.200 *M*	1.0×10^{-3} *M*	1.0×10^{-2} *M*	0.548 *M*/sec
IV.	0.400 *M*	1.0×10^{-3} *M*	2.0×10^{-2} *M*	1.096 *M*/sec

接次頁

Which of the following statements is correct?

A. The reaction is 1st order to A, B, and C.
B. Reactants A and B must be involved in the rate determine step.
C. The rate constant is 2.74×10^4 M s^{-1}
D. The equilibrium constant is 2.74×10^3
E. None of the above.

12 Acetylsalicylic acid, better known as aspirin, has the following Lewis structure:



How many carbon atoms in this molecule have sp^2 orbitals?

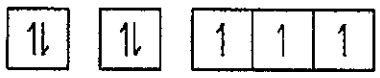
A. 7
B. 6
C. 10
D. 9
E. 8

見背面

Section B：(12%，複選題，每題全部答對 4 分，答錯一選項或以上者 0 分)

13 Which of the following orbital diagram(s) is/are consistent with the Hund's rule?

A.

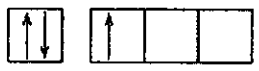


B.

C.

D.

E.



14 Which of the following statement(s) is/are correct?

A. In thermodynamics, a reversible process is a process that will take infinitely long to complete.

B. A cyclic process, either reversible or irreversible, will always return the system to its original conditions.

C. For the same amount of heat transferred between two bodies at different temperatures, the change in entropy of the body at lower temperature is always larger.

D. The change in Gibbs free energy is the maximum energy that can do work under constant pressure and temperature.

E. For a process with negative ΔG^0, the reaction cannot proceed spontaneously.

15 Which of the following description(s) about water is/are correct?

A. The pK_a of H_2O is 14

B. The pK_b of H_2O is 14

C. The sum of pK_a and pK_b of H_2O and its conjugate partner is 14

D. The conjugate acid of H_2O is H_3O^+

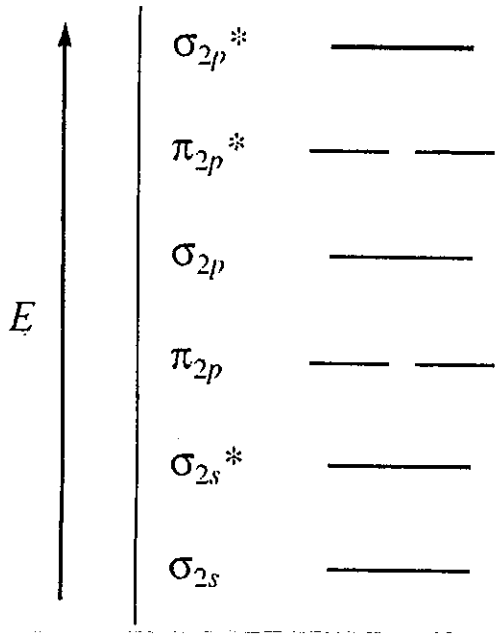
E. The pH of water at 100 °C is smaller than 7.

接次頁

※注意：請於試卷上「非選擇題作答區」標明題號並依序作答。

Section C: (40%)

1. (20%) In the following figure, we have shown the molecular orbitals for a cyanide ion (CN^-):



a. Copy the above MO in the answer sheet and fill in the electrons expected for the cyanide ion.
b. Would the ion be diamagnetic or paramagnetic?
c. What is the bond order of the cyanide ion?
d. Suppose the cyanide ion is excited by light (a laser pulse), so that an electron moves from a lower-energy to a higher-energy molecular orbital. Assume the longest possible wavelength for the excitation of the cyanide ion is used for the laser, please compare the stability of the excited cyanide ion with the unexcited cyanide ion. Explain your answer.

2. (10%) The following reduction potentials have been measured for the oxidation states of copper:

$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$ $E^0 = 0.153$ V

$Cu^+(aq) + e^- \rightarrow Cu(s)$ $E^0 = 0.521$ V

Comment on the stability of $Cu^+(aq)$. Calculate the standard free energy change and equilibrium constant at 298 K for the disproportionation of $Cu^+(aq)$.

見背面

3. (10%) Solid tin exists in two forms: white and gray. For the transformation

$$\text{Sn(s, white)} \rightarrow \text{Sn(s, gray)}$$

the enthalpy change is -2.1 kJ mol^{-1} and the entropy change is -7.4 JK^{-1} mol^{-1} at -30 °C.

a. Calculate the Gibbs free energy change for the conversion of 2.50 moles of white tin to gray tin at -30 °C.
b. Will white tin convert spontaneously to gray tin at -30 °C?
c. At what temperature are white and gray tin in equilibrium under a pressure of one atm?

試題隨卷繳回