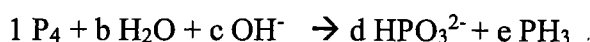


(元素分子量如下: H=1, D=2, C=12, N=14, O=16, F=19, Na=23, S = 32, Cl=35.5, P= 31, K = 39, Ca = 40, Mn = 55, Fe = 55.85, Br=80, I = 127, Faraday constant=96485 Cmol<sup>-1</sup>, Gas constant R= 8.314 J K<sup>-1</sup> mol<sup>-1</sup> ; 5.189 × 10<sup>19</sup> eV K<sup>-1</sup> mol<sup>-1</sup> or 0.082 L atm K<sup>-1</sup> mol<sup>-1</sup>, Plank Constant, h= 6.626×10<sup>-34</sup> J·s).

一. 單選題 (每題5分, 共60分)

1. a. The oxidation state of S in sulfurous acid is a.

b. Balance the following oxidation-reduction reaction, which occur in basic solution.



Question, what is the total sum of a+b+c+d+e ?

A	10
B	11
C	12
D	13
E	14

2. a. After some NaA was added into a 1.0 M HA (weak acid) solution, how does the pH of this HA solution change?

Select your answer from the following table to get your a.

(For example, if you select "smaller", then your a is 3, etc).

If your answer is	unchanged	larger	smaller
Then your a =	1	2	3

b. The product is colorless in the dimerization of yellow X gas at 25 °C.

If it was found that as the reaction temperature increasing, the color of the two gaseous mixtures is getting darker. Is this dimerization reaction an endothermic or exothermic (or cannot be determined) reaction?

Select your answer from the following table to get your b.

(For example, if you select "endothermic", then your b is 1, etc).

If your answer is	endothermic	exothermic	Cannot be determined
Then your b =	1	2	3

Question, what is the total number of your a+2 b ? (Note, b is doubled here)

A	4
B	5
C	6
D	7
E	8

3. a. At 25°C and 1 atm, 200 g sodium azide (hint: a compound with a chemical formula of  $\text{NaN}_x$ ) was completely inflated, calculate the volume (liters) of the nitrogen gas released from this sample. Select your answer from the following table to get your a. (For example, if your answer is 30-70 liters, then your a is 2, etc).

Released $\text{N}_2$ (Liter)	10-30	30-70	70-105	105-140	>140
Then your a =	1	2	3	4	5

- b. A 0.20 mole HA aqueous solution (1L; if HA with  $K_a = 1 \times 10^{-6}$ ) was added 0.1 mole NaOH, calculate the pH of this solution. Select your answer from the following table to get your b.

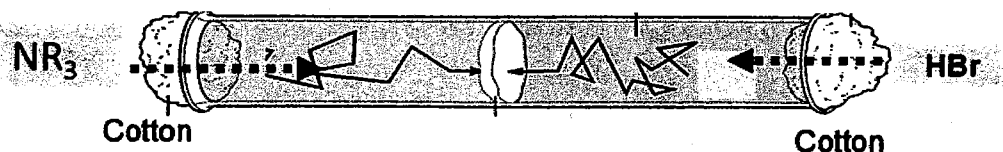
(For example, if your answer is pH ~5.0, then your b is 2, etc).

Calculated pH	~4.5	~5.0	~5.5	~6.0	~6.5
Your b =	1	2	3	4	5

Question, what is the sum of your a + b ?

A	8
B	9
C	10
D	6
E	7

4. a. As shown in the following gaseous reaction figure,  $\text{NR}_3(\text{g})$  and  $\text{HBr}(\text{g})$  will react to form the white ring of  $(\text{NR}_3\text{H})^+\text{Br}^-$ . (R=ethyl group and assumed no air existed in the reaction tube in the beginning), what will be the  $\text{NR}_3(\text{g})/\text{HBr}(\text{g})$  traveling distance ratio (r) ?



Select your answer from the following table to get your a.

(For example, if your ratio is >1.15, then your a is 5, etc).

the ratio (r) of $\text{NR}_3/\text{HBr}$	0.75-0.85	0.85-0.95	0.95-1.05	1.05-1.15	>1.15
Then your a =	1	2	3	4	5

- b. If  $\text{H}_3\text{A}$  is a triprotic acid with  $k_{a1}=1 \times 10^{-4}$ ,  $k_{a2}=1 \times 10^{-9}$ ,  $k_{a3}=1 \times 10^{-13}$ .

Calculate the pH of a 1.0 M aqueous solution of  $\text{NaH}_2\text{A}$ .

Select your answer from the following table to get your b. (For example, if your answer is  $\text{pH} < 5$ , then your b is 1).

pH	<5	5-6	6-7	7-8	>8
Then your b =	1	2	3	4	5

Question, what is the sum of your a + b ?

A	4
B	5
C	6
D	7
E	8

5. a. If  $H_3A$  is a triprotic acid with  $k_{a1}=1 \times 10^{-4}$ ,  $k_{a2}=1 \times 10^{-9}$ ,  $k_{a3}=1 \times 10^{-13}$ , calculate the equilibrium concentrations of  $[HA^{2-}]$  in a 1.0 M  $H_3A$  aqueous solution.

Select your answer from the following table to get your a. (For example, if your answer is  $\sim 10^{-7}$ , then your a is 2).

$[HA^{2-}]$	$\sim 10^{-6}$	$\sim 10^{-7}$	$\sim 10^{-8}$	$\sim 10^{-9}$	$\sim 10^{-10}$
Then your a =	1	2	3	4	5

- b. Calculate the pH of a 0.10 M  $(HNR_3)^+ X^-$  aqueous solution, if the  $K_b$  value for  $NR_3$  is  $1 \times 10^{-5}$ . ( $NR_3$  is an organic compound).

Select your answer from the following table to get your b. (For example, if your answer is 7-8, then your b is 4).

pH	$\sim 4.5$	5-6	6-7	7-8	$> 8$
Then your b =	1	2	3	4	5

Question, what is the sum of your a + b ?

A	9
B	8
C	7
D	6
E	5

6. a. For a second order reaction:  $x A \rightarrow \text{products}$

Which equation is true? ( $k$  is rate constant and  $[A]_0$  is the initial concentration of A)

Select your answer from the following table to get your a.

(For example, if your answer is  $[A] = -kt + [A]_0$ , then your a is 1, etc).

True equation	$[A] = -kt + [A]_0$	$\ln[A] = -kt + \ln[A]_0$	$\ln[A] = kt - \ln[A]_0$
your a =	1	2	3

(Continue from above table)

True equation	$1/[A] = -kt + 1/[A]_0$	$1/[A] = kt + 1/[A]_0$
your a =	4	5

**b. Continue from 6a.** What is the half-life ( $t_{1/2}$ ) for the above second order reaction?

Select your answer from the following table to get your **b**.

(For example, if your half-life ( $t_{1/2}$ ) is  $0.639/[A]_0$ , then your **b** is **1**, etc).

Half-life ( $t_{1/2}$ )	$0.639/[A]_0$	$0.693/(k[A]_0)$	$1/(k[A]_0)$	$0.693/k$	$[A]_0/(2k)$	$[A]_0/k$
your <b>b</b> =	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>

**Question, what is the sum of your a + b ?**

<b>A</b>	<b>4</b>
<b>B</b>	<b>5</b>
<b>C</b>	<b>6</b>
<b>D</b>	<b>7</b>
<b>E</b>	<b>8</b>

**7. a.** For a certain reaction with rate constant of  $k_1$  at temperature  $T_1$  and rate constant of  $k_2$  at temperature  $T_2$ , which equation is true to obtain the  $E_a$  (activation energy) of this reaction?

Select your answer from the following table to get your **a**.

(For example, if your answer is  $\ln(k_2/k_1) = (R/E_a) * [(1/T_1) - (1/T_2)]$ , then your **a** is **1**, etc).

$\ln(k_2/k_1) =$	$(R/E_a) * [(1/T_1) - (1/T_2)]$	$-(R/E_a) * [(1/T_1) - (1/T_2)]$	$-(E_a/R) * [(1/T_1) - (1/T_2)]$
Then your <b>a</b> =	<b>1</b>	<b>2</b>	<b>3</b>

(Continue from above table)

$\ln(k_2/k_1) =$	$(E_a/R) * [(1/T_1) - (1/T_2)]$	None of above equation is correct
Then your <b>a</b> =	<b>4</b>	<b>5</b>

**b.** For a reaction:  $A + w B + x C \longrightarrow y D + z E$  (A-E are 5 different compounds).

The following reaction rates are obtained from the method of initial rate, by varying the starting concentration of three reactants A, B, and C. Use the following results to determine the overall reaction order (**b**) for this reaction.

Exp	A (M)*	B (M)*	C (M)*	Measured Rate
1	0.2	0.1	0.2	0.0008
2	0.1	0.2	0.2	0.0032
3	0.2	0.1	0.1	0.0002
4	0.1	0.1	0.2	0.0004

(\* M is molarity)

Select your answer from the following table to get your **b**.

(For example, if your overall reaction order is **4**, then your **b** is **2**, etc).

Overall reaction order =	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
Then your <b>b</b> =	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

Question, what is the sum of your a + b = ?

A	8
B	9
C	10
D	11
E	12

8. One mole ideal gas at the pressure of 4 atm with a volume of 2 L takes an adiabatic expansion to the pressure of 2 atm. Which of the following volume is CORRECT at 2 atm?
- A. 3.03 L  
B. 4.00 L  
C. 5.00 L  
D. 6.00 L  
E. 7.00 L
9. Which of the following statements is INCORRECT in thermodynamics?
- A. The energy of the universe is constant.  
B. The entropy of the universe is always increasing.  
C. For an irreversible process, the change of entropy for the system is larger than zero.  
D. The molar heat capacity of diatomic molecules is smaller than that of ideal gas.  
E. At equilibrium, the change of free energy ( $\Delta G$ ) is zero.
10. To balance the chemical reaction:  $\text{Cr}_2\text{O}_7^{2-} + \text{I}_2 + \text{H}^+ \rightarrow \text{IO}_3^- + \text{Cr}^{3+} + \text{H}_2\text{O}$ . What is the coefficient for  $\text{Cr}^{3+}$ ?
- A. 2  
B. 5  
C. 6  
D. 10  
E. 20
11. Which of the following statements is INCORRECT in quantum mechanics?
- A. Heisenberg's Uncertainty Principle:  $\Delta E \Delta t \geq \frac{\hbar}{2}$   
B. Wave functions must be continuous.  
C. momentum operator:  $+i\hbar \frac{d}{dx}$   
D. kinetic energy operator:  $-\frac{\hbar^2}{2m} \nabla^2$   
E. de Broglie's formula:  $p = \frac{h}{\lambda}$

12. Which of the following statements is INCORRECT?

- A. For atomic orbitals, the size is dependent of principal quantum number ( $n$ ) and angular momentum quantum number ( $\ell$ ).
- B. For the  $3s$  atomic orbital, there are three nodes in the radial function.
- C. For copper (Cu,  $Z=29$ ), the ground state electronic configuration is  $[\text{Ar}]3d^{10}4s^1$ .
- D. For one-electron atoms such as hydrogen, the atomic orbital energy is only dependent of principal quantum number ( $n$ ).
- E. Helium (He) has highest 1<sup>st</sup> ionization energy among all elements.

二. 複選題 (全對才給分, 每題5分, 共25分)

13. Which of following molecules have  $sp^2$  hybridization in the central atom?

- A.  $\text{NH}_3$
- B.  $\text{CO}_3^{2-}$
- C.  $\text{SO}_2$
- D.  $\text{SO}_4^{2-}$
- E.  $\text{I}_3^-$

14. With respect to the  $\text{O}_2$  molecule, which of the following statements are CORRECT?

- A. The bond order of  $\text{O}_2$  is 2.
- B.  $\text{O}_2$  is diamagnetic.
- C. Bond distance  $\text{O}_2^+ < \text{O}_2 < \text{O}_2^-$ .
- D. The energy of  $\sigma_{2p}$  bonding orbital is higher than that of  $\pi_{2p}$  bonding orbital.
- E. The energy of  $\sigma_{2p}^*$  anti-bonding orbital is higher than that of  $\pi_{2p}^*$  anti-bonding orbital.

15. Which of the following statements about intermolecular interactions are CORRECT?

- A. London dispersion force:  $\text{F}_2 < \text{Cl}_2 < \text{Br}_2$ .
- B. Usually, the hydrogen bond is stronger than London dispersion force.
- C. The radial dependence of potential energy of London dispersion force is  $R^{-3}$ .
- D. The radial dependence of potential energy of dipole-dipole force in liquids is  $R^{-2}$ .
- E. Hydrogen bond can occur between hydrogen and N, O, F atoms.

16. Which of the following statements about solutions and colloids are CORRECT?

- A. A colloid is formed by electrostatic repulsion.
- B. Tyndall effect can be used to distinguish a colloid and a solution.
- C. The solubility of gases in water usually increases as temperature increases.
- D. The solubility of gases in water usually can be described by Henry's Law.
- E. Pressure has little effect on the solubility of solids such as  $\text{NaCl}_{(s)}$  in water..

