

# 2016 年第 33 届全国华文独中数理学识比赛 - 化学

下列元素周期表资料，可供回答问题之参考

1																	2
H																	He
1.0																	4.0
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
6.9	9.0											10.8	12.0	14.0	16.0	19.0	20.2
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
23.0	24.0											27.0	28.1	31.0	32.0	35.5	40.0
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.1	40.1	45.0	47.9	50.9	52.0	54.9	55.8	58.9	58.7	64.0	65.4	69.7	72.6	74.9	79.0	80.0	83.8

## 选择题

1. 在  $-80^{\circ}\text{C}$  时， $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$  的平衡常数  $K$  为  $4.66 \times 10^{-8}$ 。若於相同温度下，将若  $0.034 \text{ mol}$  的  $\text{N}_2\text{O}_4(\text{g})$  气体置于  $2.5$  公升的反应瓶内並让其达到平衡，试问在平衡时的压力共计应为多少？

At  $-80^{\circ}\text{C}$ , the equilibrium constant  $K$  for the reaction  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$  is  $4.66 \times 10^{-8}$ . If  $0.034 \text{ mol}$  of  $\text{N}_2\text{O}_4$  gas was introduced into a  $2.5\text{-L}$  vessel at  $-80^{\circ}\text{C}$  and equilibrium was established, what would be the total pressure in the system?  $[R=0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}]$

- A)  $0.24 \text{ atm}$ .    B)  $0.22 \text{ atm}$ .    C)  $0.09 \text{ atm}$ .    D)  $0.43 \text{ atm}$ .    E)  $4.66 \times 10^{-8} \text{ atm}$ .
2. 在一瓶水溶液中含有  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$  和  $\text{Ni}^{2+}$  三种阳离子，可借由  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$  和  $\text{Na}_2\text{S}$  三种稀水溶液将其区分。达到有效率的分离加入的顺序应为如何？
- An aqueous solution contains  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ , and  $\text{Ni}^{2+}$  cations. Dilute aqueous solutions of  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ , and  $\text{Na}_2\text{S}$  are available to differentiate these cations from each other. In order to have effective differentiation among these cations, in which order the solutions should be added?
- A)  $\text{Na}_2\text{SO}_4$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{S}$   
 B)  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{S}$ ,  $\text{NaCl}$   
 C)  $\text{Na}_2\text{S}$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$   
 D)  $\text{NaCl}$ ,  $\text{Na}_2\text{S}$ ,  $\text{Na}_2\text{SO}_4$   
 E)  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{S}$

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3. 铜的平均原子量为 63.5，以两种同位素存在於自然界中。已知其中之一的原子量为 62.9amu，且含量占两种同位素中的 69.1%，试问另一个含量为 30.9% 之同位素其原子量为多少？

The average atomic weight of copper, which has two naturally occurring isotopes, is 63.5. One of the isotopes has an atomic weight of 62.9 amu and constitutes 69.1%. The other isotope has an abundance of 30.9%, what is its atomic weight (amu)?

- A) 63.2      B) 63.8      C) 64.1      D) 64.8      E) 28.1

4. 丙烷与空气中的氧气反应后会形成二氧化碳和水。在一个特别实验中氧气反应后会形成二氧化碳和水，将 22.05 克的丙烷与过量的氧气反应后产生了 38.1 克的二氧化碳，试问此反应的产率应为多少%？

Propane ( $C_3H_8$ ) reacts with oxygen in the air to produce carbon dioxide and water. In a particular experiment, 38.1 grams of carbon dioxide are produced from the reaction of 22.05 grams of propane with excessive oxygen. What is the percentage yield in this reaction?

- A) 38.1      B) 57.6      C) 66.0      D) 86.4      E) 94.5

5. 在下列的反应中，哪一个并非自发反应？

Of the following reactions, which one is **not** spontaneous?

- A)  $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$   
B)  $2Ag(s) + 2HNO_3(aq) \rightarrow 2AgNO_3(aq) + H_2(g)$   
C)  $2Ni(s) + H_2SO_4(aq) \rightarrow Ni_2SO_4(aq) + H_2(g)$   
D)  $2Al(s) + 6HBr(aq) \rightarrow 2AlBr_3(aq) + 3H_2(g)$   
E)  $Zn(s) + 2HI(aq) \rightarrow ZnI_2(aq) + H_2(g)$

6. 试计算浓度为 0.10 M 的 HOCl 水溶液之 pH 值， $K_a = 3.5 \times 10^{-8}$ 。

Calculate the pH of a 0.10 M aqueous solution of HOCl,  $K_a = 3.5 \times 10^{-8}$ .

- A) 4.2      B) 8.5      C) 3.7      D) 1.0      E) 3.2

7. 单体  $NH_2(CH_2)_5COOH$  形成的聚合物是.....

The polymer formed from  $NH_2(CH_2)_5COOH$  monomer is a .....

- A) 蛋白质 Protein  
B) 聚酯 Polyester  
C) 聚乙烯 Polyethylene  
D) 有机玻璃 Organic glass  
E) 聚酰胺 Polyamide

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8. 对两个質量相同但比热不同的金属供給相同的热能。試問哪一個金属其温度的改变較小？

Two metals of equal mass with different heat capacities are subjected to the same amount of heat. Which metal undergoes the smaller change in temperature?

A) 比热較大的金属

The metal with the higher heat capacity.

B) 比热較小的金属

The metal with the lower heat capacity.

C) 两金属變改变的温度相同

Both undergo the same change in temperature.

D) 为了正确決定，須測量两种金属的分別起始温度

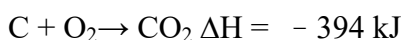
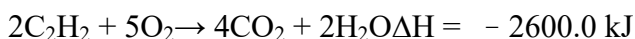
To determine this, you need to know the initial temperatures of the metals.

E) 为了正确決定，需知道两种金属的种类。

To determine this, you need to know which metals you are talking about.

9. 在 25°C 時，下述反应的焓变分別为.....

At 25°C, the enthalpy change of each of the following reactions is given.



試計算下列反应在相同温度下的焓变。

Calculate the enthalpy change at the same temperature of the following reaction.



A) 226 kJ      B) -226 kJ      C) 2422 kJ      D) -2422 kJ

E) 以上皆非 None of the above.

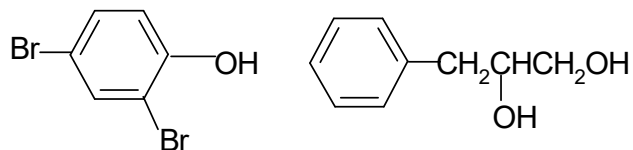
10. 試問硫原子在其基态的时候具有几个未配对的电子？

How many unpaired electrons are there in sulfur atom at its ground state?

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

11. 那一項試劑可以檢驗分別以下的两个有机化合物？

Which reagent could differentiate the following two organic compounds?



- (I)  $\text{KMnO}_4$  溶液 solution      (II)  $\text{AgNO}_3$  溶液 solution  
 (III)  $\text{NaOH}$  溶液 solution      (IV) 金属钠 sodium metal

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

E) 其他的组合 None of the above

12. 在下列的等电子体（相同电子组态）中，半径大小的排列何者正确？

Which isoelectronic series is correctly arranged in increasing order of radii?

- A)  $\text{K}^+ < \text{Ca}^{2+} < \text{Ar} < \text{Cl}^-$   
 B)  $\text{Cl}^- < \text{Ar} < \text{K}^+ < \text{Ca}^{2+}$   
 C)  $\text{Ca}^{2+} < \text{Ar} < \text{K}^+ < \text{Cl}^-$   
 D)  $\text{Ca}^{2+} < \text{K}^+ < \text{Ar} < \text{Cl}^-$   
 E)  $\text{Ca}^{2+} < \text{K}^+ < \text{Cl}^- < \text{Ar}$

13. 在下列的各键中，何者具最高极性但又不是离子键？

Which of the following bonds would be the most polar without being considered ionic?

- A)  $\text{Mg}-\text{O}$     B)  $\text{C}-\text{O}$                       C)  $\text{O}-\text{O}$                       D)  $\text{Si}-\text{O}$                       E)  $\text{N}-\text{O}$

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14. 下表为一氧化氮与氧气反应的起始浓度与反应速率关系数据。(浓度单位 molecules/cm<sup>3</sup>, 速率单位 molecules/cm<sup>3</sup> · s, 初始速率=Initial Rate)。

The following data were obtained for the reaction of NO with O<sub>2</sub>. Concentrations are in molecules/cm<sup>3</sup> and rates are in molecules/cm<sup>3</sup> · s.

[NO] <sub>0</sub>	[O <sub>2</sub> ] <sub>0</sub>	Initial Rate
1 x 10 <sup>18</sup>	1 x 10 <sup>18</sup>	2.0 x 10 <sup>16</sup>
2 x 10 <sup>18</sup>	1 x 10 <sup>18</sup>	8.0 x 10 <sup>16</sup>
3 x 10 <sup>18</sup>	1 x 10 <sup>18</sup>	18.0 x 10 <sup>16</sup>
1 x 10 <sup>18</sup>	2 x 10 <sup>18</sup>	4.0 x 10 <sup>16</sup>
1 x 10 <sup>18</sup>	3 x 10 <sup>18</sup>	6.0 x 10 <sup>16</sup>

以下哪项是正确的速率定律? Which of the following is the correct rate law?

- A) Rate 速率 =  $k[\text{NO}][\text{O}_2]$   
 B) Rate 速率 =  $k[\text{NO}][\text{O}_2]^2$   
 C) Rate 速率 =  $k[\text{NO}]^2[\text{O}_2]$   
 D) Rate 速率 =  $k[\text{NO}]^2$   
 E) Rate 速率 =  $k[\text{NO}]^2[\text{O}_2]^2$
15. 有学生将一个化学分子命名为"2-乙基-3-甲基-5-异丙基己烷", 然而助教指出此分子虽可藉由上述名称画出正确结构式, 但此命名方式违反了系统命名原则。请依照国际纯粹与应用化学联合会(IUPAC)的命名法则给予此分子正确的命名。

A student named a molecule as 2-ethyl-3-methyl-5-isopropylhexane. However, his tutor pointed out that although the molecule could be correctly drawn from this name, the name violates the systematic rules. What is the correct IUPAC name for the molecule?

- A) 3,4-dimethyl-6-isopropylheptane(3,4-二甲基-6-异丙基庚烷)  
 B) 2-isopropyl-4,5-dimethylheptane (2-异丙基-4,5-二甲基庚烷)  
 C) 3,4,6,7-tetramethyloctane(3,4,6,7-四甲基辛烷)  
 D) 1,2-diethyl-3,6,7-trimethylheptane(1,2-二乙基-3,6,7-三甲基庚烷)  
 E) 2,3,5,6-tetramethyloctane (2,3,5,6-四甲基辛烷)
16. 在 SiO<sub>4</sub><sup>4-</sup> 的结构中, 以矽原子为中心的氧原子排列为何种形状?  
 What is the structural arrangement of oxygen atoms around a silicon atom in SiO<sub>4</sub><sup>4-</sup>?
- A) square planar (平面四边形)  
 B) octahedral (八面体)  
 C) linear (直线型)  
 D) tetrahedral (四面体)  
 E) trigonal pyramidal (双三角锥)

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17. 下表为五个化合物的分子量(molecular mass)与偶极矩(dipole moment)，请推测何者具有最高的沸点？

Based on molecular mass and dipole moment of the five compounds in the table below, which compound should have the highest boiling point?

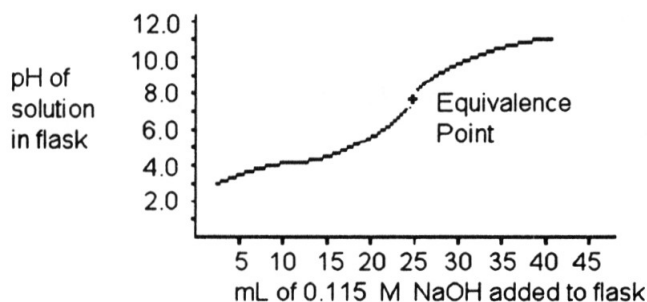
Substance	Molecular Mass (amu)	Dipole Moment (D)
Propane, CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	44	0.1
Dimethylether, CH <sub>3</sub> OCH <sub>3</sub>	46	1.3
Methylchloride, CH <sub>3</sub> Cl	50	1.9
Acetaldehyde, CH <sub>3</sub> CHO	44	2.7
Acetonitrile, CH <sub>3</sub> CN	41	3.9

- A) CH<sub>3</sub>CH<sub>2</sub>CH<sub>3</sub> (Propane, 丙烷)  
 B) CH<sub>3</sub>OCH<sub>3</sub> (Dimethylether, 二甲醚)  
 C) CH<sub>3</sub>Cl (Methylchloride, 氯甲烷)  
 D) CH<sub>3</sub>CHO (Acetaldehyde, 乙醛)  
 E) CH<sub>3</sub>CN (Acetonitrile, 乙腈)
18. 將氟化鈉(NaF)溶液逐滴加入含有 0.0122M 钡离子(Ba<sup>2+</sup>)的溶液中，当溶液中氟离子(F<sup>-</sup>)浓度超過多少时，会有氟化钡(BaF<sub>2</sub>)的沉淀产生？(体积改变可忽略，BaF<sub>2</sub>的 K<sub>sp</sub> = 1.7 × 10<sup>-6</sup>)  
 A solution of NaF is added dropwise to a solution containing 0.0122 M Ba<sup>2+</sup>. What is the concentration of F<sup>-</sup> that would cause the precipitation of BaF<sub>2</sub>? (Neglect volume changes, given K<sub>sp</sub> of BaF<sub>2</sub> = 1.7 × 10<sup>-6</sup>)  
 A) 7.0 × 10<sup>-5</sup> B) 1.2 × 10<sup>-2</sup> C) 2.1 × 10<sup>-8</sup> D) 3.0 × 10<sup>-3</sup> E) 1.4 × 10<sup>-4</sup>
19. 下列水溶液中，何者具有最高浓度的羟基(OH<sup>-</sup>)?  
 Which of the following aqueous solution has the highest concentration of hydroxyl (OH<sup>-</sup>)?  
 A) pH = 3.0 的水溶液 aqueous solution with pH = 3.0  
 B) 1 × 10<sup>-4</sup> M 的硝酸水溶液 1 × 10<sup>-4</sup> M aqueous solution of HNO<sub>3</sub>  
 C) pOH = 12.0 的水溶液 aqueous solution with pOH = 12.0  
 D) 純水 pure water  
 E) 1 × 10<sup>-3</sup> M 的氯化铵水溶液 1 × 10<sup>-3</sup> M aqueous solution of NH<sub>4</sub>Cl

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20. 以 0.115 M 的氢氧化钠水溶液去滴定一个 25.0 mL 的未知溶液，其滴定曲线如下图所示，由实验结果我们可推测此未知溶液的当量点(Equivalence point)。试问未知化合物的溶液是什么类型？

A 25.0 mL sample of a solution of an unknown compound is titrated with a 0.115 M NaOH solution. The following titration curve was obtained and the equivalence point can be determined. What is the unknown solution?

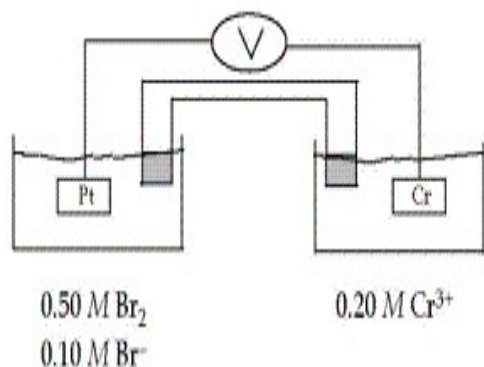


- A) 一个强酸性溶液 a strong acidic solution  
 B) 一个强碱性溶液 a strong alkaline solution  
 C) 一个弱酸性溶液 a weak acidic solution  
 D) 一个弱碱性溶液 a weak alkaline solution  
 E) 并非酸性或碱性溶液 neither an acidic nor alkaline solution
21. 在下列的电子组态中，哪一个原子具有最低的第二游离能？  
 Among the following electron configurations, which atom has the lowest second ionization energy ?
- A)  $1s^2 2s^2 2p^6 3s^1$   
 B)  $1s^2 2s^2 2p^6 3s^2$   
 C)  $1s^2 2s^2 2p^6 3s^2 3p^1$   
 D)  $1s^2 2s^2 2p^6 3s^2 3p^4$   
 E)  $1s^2 2s^2 2p^6 3s^2 3p^5$
22. 一含有氮气样品的容器被另一个未知分子量的气体 A 污染，已知在 25°C，容器内气体 A 与氮气的分压皆为 200 torr。若让容器内的两气体经由针孔逸散，气体 A 的逸散速度较氮气快 2.65 倍，试计算此气体 A 的摩尔质量。  
 A sample of  $N_2$  gas is contaminated with gas A of unknown molar mass. The partial pressure of each gas is known to be 200 torr at 25°C. When the gases are allowed to effuse through a pinhole, gas A escapes at 2.65 times the rate of  $N_2$ . Calculate the molar mass of gas A.
- A) 3.99 g/mol  
 B) 197 g/mol  
 C) 74.2 g/mol  
 D) 10.6 g/mol  
 E) 以上皆非(None of the above)

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◆ 請以下图的伏打电池结构及两个标准还原电位回答 23 和 24 题。

Consider the galvanic cell as shown in the diagram below and the two standard reduction potentials to answer questions of 23 and 24.



标准还原电位

The standard reduction potentials



23. 请问此电池的标准电位  $E^{\circ}$  为多少？

What is  $E^{\circ}$  for this cell?

- A) 1.82 V      B) 0.36 V      C) 4.73 V      D) 1.70 V      E) 4.40 V

24. 關於此电池的以下敘述何者錯誤？

Which of the following statement about this cell is false?

A) 这是一个伏打电池 This is a galvanic cell.

B) 外部电子由鉑电极流向鉻电极

External electron flows from Pt electrode to Cr electrode.

C) 还原反应发生在鉑电极。Reduction occurs at the Pt electrode.

D) 這電池並未處於标准状态。The cell is not at standard conditions.

E) 为了完成电流通路，盐桥内的阳离子朝左侧半电池移动，阴离子则朝右侧的半电池移动

To complete the circuit, cations migrate into the left half-cell and anions migrate into the right half-cell from the salt bridge.

25. 下列含氙化合物中，何者为极性分子？

Consider the following xenon compounds: Which of them are polar molecules?

- (i)  $\text{XeF}_2$       (ii)  $\text{XeF}_4$       (iii)  $\text{XeO}_4$       (iv)  $\text{XeOF}_4$       (v)  $\text{XeO}_3$

A) 只有(i)      only (i)

B) (ii)和(iii)      (ii) and (iii)

C) 只有(iv)      only (iv)

D) (iii)和(iv)      (iii) and (iv)

E) (iv)和(v)      (iv) and (v)