

**2022 年第三十七屆成大數理比賽 - 化學**  
**37<sup>th</sup> NCKU Science and Mathematics Competition 2022 - Chemistry**

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

1.  $\text{SO}_2$  和  $\text{H}_2\text{S}$  的反應式是  $2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 3\text{S} + 2\text{H}_2\text{O}$   
 當 7.50 克的  $\text{H}_2\text{S}$  與 12.75 克的  $\text{SO}_2$  發生反應，會出現什麼結果？  
 $\text{SO}_2$  reacts with  $\text{H}_2\text{S}$  as follows:  $2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 3\text{S} + 2\text{H}_2\text{O}$   
 When 7.50 g of  $\text{H}_2\text{S}$  reacts with 12.75 g of  $\text{SO}_2$ , what would be the outcome?
- (A) 產生 6.38 克的硫。  
 6.38 g of sulfur is formed.
- (B) 剩下 1.13 克的  $\text{H}_2\text{S}$ 。  
 1.13 g of  $\text{H}_2\text{S}$  remains.
- (C) 剩下 0.0216 莫耳的  $\text{H}_2\text{S}$ 。  
 0.0216 mol of  $\text{H}_2\text{S}$  remains.
- (D) 產生 10.6 克的硫。  
 10.6 g of sulfur is formed.
- (E)  $\text{SO}_2$  是限量試劑。  
 $\text{SO}_2$  is the limiting reagent.

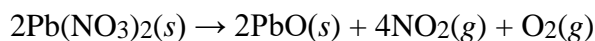
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2. 將硝酸銀和鉻酸鉀的水溶液混合後，會形成血紅色的鉻酸銀沉澱。如果將 10.0 mL 0.25 M 硝酸銀水溶液與 15.0 mL 的 0.14 M 鉻酸鉀水溶液混合，溶液中離子的總濃度是多少？

When aqueous solutions of silver nitrate and potassium chromate are mixed, the blood-red silver chromate precipitate is produced. If 10.0 mL of 0.25 M aqueous silver nitrate is mixed with 15.0 mL of 0.14 M aqueous potassium chromate, what would be the total concentration of ions in the solution?

- (A) 0.14 M  
(B) 0.39 M  
(C) 0.30 M  
(D) 0.50 M  
(E) 0.25 M

3. 將 3.82 g 的硝酸鉛(II),  $\text{Pb}(\text{NO}_3)_2$ , 在容積為 1.70 L 的抽空圓筒中加熱。鹽根據以下方程式分解



設其完全分解，冷卻至 290K 時，圓筒中的壓力是多少？

3.82 g of lead(II) nitrate,  $\text{Pb}(\text{NO}_3)_2$ , is heated in an evacuated cylinder with a volume of 1.70 L.

The salt decomposes, according to the following equation



Assuming complete decomposition, what is the pressure in the cylinder after cooling to a temperature of 290 K?

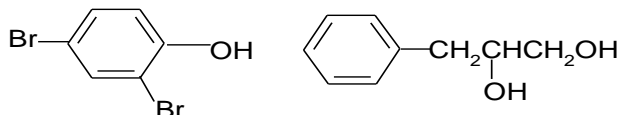
[通用氣體常數 Universal gas constant  $R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$  ]

- (A) 0.565 atm  
(B) 0.262 atm  
(C) 0.784 atm  
(D) 0.808 atm  
(E) 0.404 atm

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4. 那一項試劑可以用於檢驗分別以下有機化合物?

Which of the following reagent could be used to differentiate the following organic compounds?



(I)  $\text{AgNO}_3$  溶液 solution

(II)  $\text{KOH}$  溶液 solution

(III) 金屬鈉 sodium metal

(IV)  $\text{KMnO}_4$  溶液 solution

(A) I,II,III

(B) I, III

(C) II,IV

(D) IV

(E) 以上皆非。None of the above.

5. 什麼濃度的  $\text{HF}$  ( $K_a = 7.2 \times 10^{-4}$ ) 將會與  $0.070 \text{ M}$  的  $\text{HCl}$  有相同的 pH 值?

What concentration of  $\text{HF}$  ( $K_a = 7.2 \times 10^{-4}$ ) would have the same pH as that of  $0.070 \text{ M HCl}$ ?

(A)  $6.8 \text{ M}$

(B)  $5.0 \times 10^{-6} \text{ M}$

(C)  $1.0 \times 10^{-2} \text{ M}$

(D)  $0.070 \text{ M}$

(E)  $0.15 \text{ M}$

6. 单体  $\text{HO}-(\text{CH}_2)_7\text{COOH}$  形成的聚合物是...

The polymer formed from  $\text{HO}-(\text{CH}_2)_7\text{COOH}$  monomer is a ...

(A) Polyamide 聚酰胺

(B) Polyethylene 聚乙烯

(C) Polyester 聚酯

(D) Protein 蛋白質

(E) Carbohydrate 醣類

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7.  $\text{C}_2\text{H}_5\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$ ,  $\Delta H = -1.37 \times 10^3 \text{ kJ}$   
上式為乙醇的燃燒反應式，以下哪個說法是正確的？

The above represents the combustion reaction of ethanol. Which of the following statements is (are) true?

- I. The reaction is exothermic. 這是放熱反應。  
II. The enthalpy change would be different if gaseous water were produced.  
若產生氣態水，焓變會不一樣。  
III. It is not a Redox reaction. 該反應不是氧化還原反應。  
IV. The products of the reaction occupy a larger volume than the reactants.  
生成物比反應物佔據更大的體積。

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

8. 從  $\text{CuSO}_4$  水溶液中電鍍銅。提供 4.70 安培的恆定電流，沉積  $3.76 \times 10^2$  克銅需要多長時間？

Copper is electroplated from an aqueous  $\text{CuSO}_4$  solution. A constant current of 4.70 amp is applied, how long will it take to deposit  $3.76 \times 10^2 \text{ g}$  of Cu?

[ 1 Faraday 法拉第 =  $96500 \text{ C mol}^{-1}$  ]

- (A) 33.7 h  
(B) 101 h  
(C) 2.08 h  
(D) 67.5 h  
(E) 135 h

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9. 下列哪個離子具有平面結構?

Which of the following ion has planar structure?

- (A)  $\text{SO}_3^{2-}$
- (B)  $\text{PCl}_4^+$
- (C)  $\text{ClO}_3^-$
- (D)  $\text{SCl}_5^-$
- (E)  $\text{CO}_3^{2-}$

10. A 和 B 反應形成 C，下表為其初始反應速率。請問其反應的速率定律式為何?

A reacts with B to form C, and the following is the initial rate data.

What is the rate law for the reaction?

[A] <sub>0</sub> /mol/L	[B] <sub>0</sub> /mol/L	C 生成速率 mol/L s <sup>-1</sup> Rate of formation of C
0.300	0.300	2.80
0.300	0.150	0.700
0.600	0.150	1.40

- (A) Rate =  $k[\text{A}]^2[\text{B}]^2$
- (B) Rate =  $k[\text{A}]^2[\text{B}]$
- (C) Rate =  $k[\text{A}][\text{B}]^2$
- (D) Rate =  $k[\text{A}][\text{B}]$
- (E) Rate =  $k[\text{A}]^3$

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11. *p*-型半導體....

A *p*-type semiconductor....

- (A) 通過摻雜比主體原子更多的價電子的原子來製備。  
is made by doping host atoms with atoms having more valence electrons than the host.
- (B) 具有能量接近導帶的電子。  
has electrons that lie close in energy to the conduction bands.
- (C) 通過摻雜比主體原子更少的價電子的原子來製備。  
is made by doping host atoms with atoms having fewer valence electrons.
- (D) 兩種上述答案。  
two of these.
- (E) 以上皆非。  
none of these.

12. 當氧氣壓力為 15 大氣壓時，氧的溶解度為 0.590 g/L。

請問氧的亨利定律常數為何(單位為 L atm/mol) ?

The solubility of O<sub>2</sub> in water is 0.590 g/L at oxygen pressure of 15 atm.

What is the Henry's law constant for O<sub>2</sub> (in units of L atm/mol)?

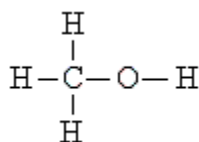
- (A)  $3.93 \times 10^{-3}$
- (B)  $1.23 \times 10^{-3}$
- (C)  $8.14 \times 10^2$
- (D) 1.26
- (E) 上述答案皆不在正確答案的 5% 誤差內。  
None of the above is within 5% of the correct answer.

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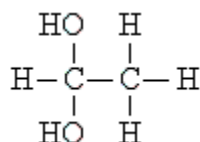
13. 從下圖中找出具有光學活性的化合物:

Pick the optically active molecule among the following:

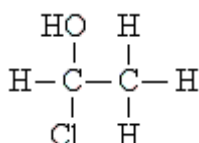
(A)



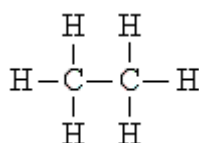
(B)



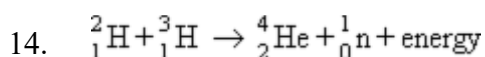
(C)



(D)



(E) None of these. 以上皆非。



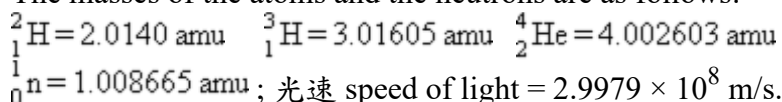
一種有希望能解決未來能源危機的方式是使用核融合。根據上述反應式，請問一莫耳的氘與一莫耳的氚進行核融合反應會產生多少能量？

One of the hopes for solving the world's energy crisis is to make use of the fusion reaction.

How much energy is released when 1 mol of deuterium is fused with 1 mol of tritium according to the above reaction?

下圖是原子與中子的質量

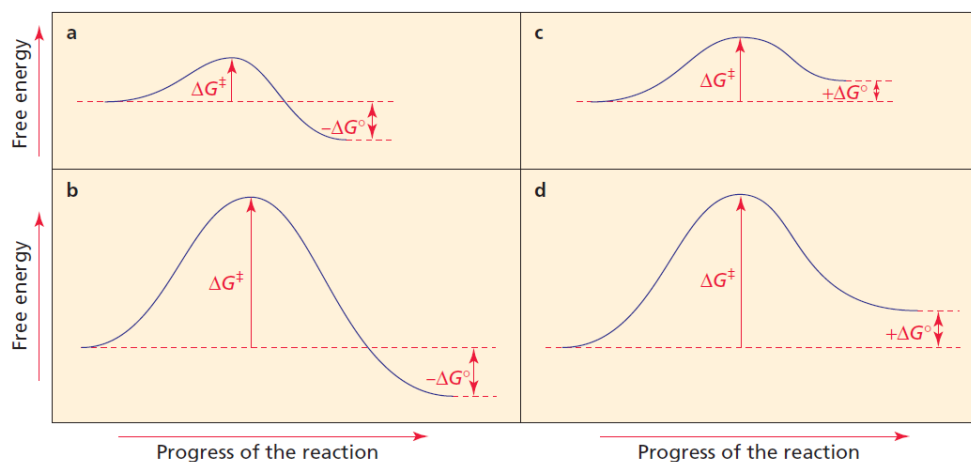
The masses of the atoms and the neutrons are as follows:



- (A)  $1.69 \times 10^{12} \text{ J}$   
 (B)  $5.63 \times 10^8 \text{ J}$   
 (C)  $8.44 \times 10^{11} \text{ J}$   
 (D)  $7.84 \times 10^{44} \text{ J}$   
 (E)  $56.3 \text{ J}$

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15. 根據下列四個反應路徑圖，判斷哪個反應具有最穩定之動力學產物？  
According to the four reaction coordinate diagrams below, which of them has the most kinetically stable product?



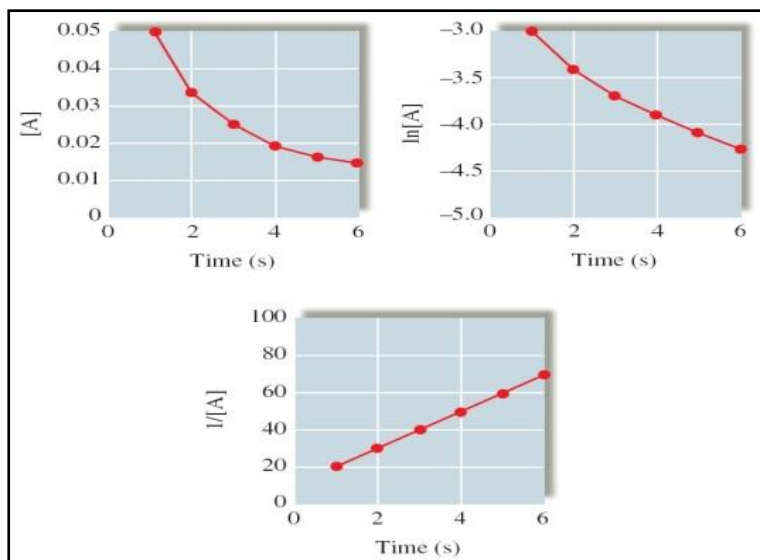
- (A) a                      (B) b                      (C) c  
(D) d                      (E) None of these. 以上皆非。



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16. 以三種不同方法繪製  $A \rightarrow 2B + C$  之實驗數據圖如下所示，請判斷 A 之反應為幾級反應？及反應物 A 之初始濃度？

Experimental data for the reaction  $A \rightarrow 2B + C$  have been plotted in the following three different ways. What is the order of the reaction respect to A and what is the initial concentration of A ?



- (A) 一級反應; 0.1M  
first order; 0.1 M
- (B) 二級反應; 1M  
second order; 1 M
- (C) 零級反應; 0.01M  
zero order, 0.01 M
- (D) 一級反應; 1M  
first order; 1 M
- (E) 二級反應; 0.1M  
second order; 0.1 M

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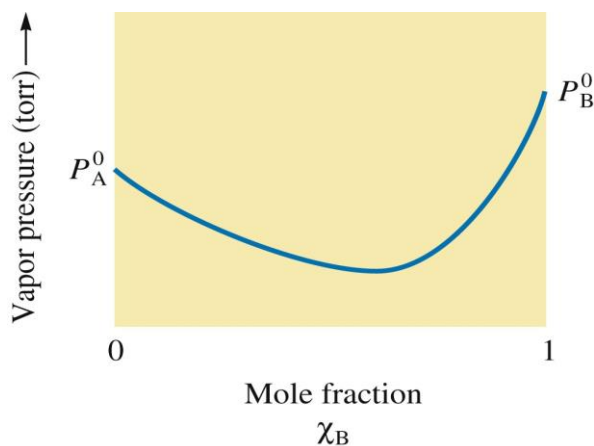
17. 下列敘述何者正確?

Which of the following statements is true?

- (A) 在 25 °C 時 LiF 的蒸氣壓比 H<sub>2</sub>S 的大。  
LiF has higher vapor pressure than H<sub>2</sub>S at 25 °C.
- (B) 在 -50 °C 時 HF 比 HBr 有較高的蒸氣壓。  
At -50 °C, HF has higher vapor pressure than HBr.
- (C) Cl<sub>2</sub> 的沸點大於 Ar。  
Cl<sub>2</sub> has higher boiling point than Ar.
- (D) HCl 在水的溶解度小於 CCl<sub>4</sub>。  
HCl is less soluble in water than in CCl<sub>4</sub>.
- (E) 在 25 °C 時 MgO 的蒸氣壓比 CH<sub>3</sub>CH<sub>2</sub>OH 的大。  
At 25 °C, MgO has higher vapor pressure than CH<sub>3</sub>CH<sub>2</sub>OH.

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18. 下圖顯示在相同溫度下不同摩尔比例的 A 和 B 溶液的蒸氣壓。  
The following plot shows the vapor pressure of solution of mixing different molar ratio of A and B at constant temperature.

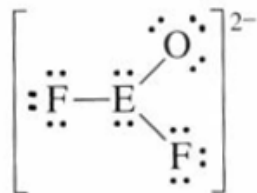


下列敘述何者為非？ Which of the following statements is false?

- (A) 溶液顯示為拉午耳定律的負偏差。  
The solution exhibits negative deviation from Raoult's law.
- (B)  $\Delta H_{\text{soln}}$  應為吸熱。  
 $\Delta H_{\text{soln}}$  is endothermic.
- (C) 分子間力在溶液中比在純物質 A 或純物質 B 中來的強。  
The intermolecular forces are stronger in solution than in either pure A or pure B.
- (D) 純液體 B 比純液體 A 容易揮發。  
Pure liquid B is more volatile than pure liquid A.
- (E)  $\chi = 0.6$  的溶液比純物質 A 或純物質 B 的沸點高。  
The solution with  $\chi = 0.6$  will have a higher boiling point than either pure A or pure B.

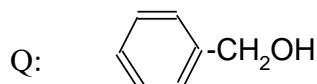
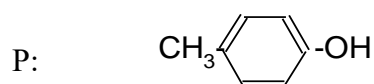
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19. 下圖為一路易士結構，其中 E 為未知元素，請問以下敘述何者正確？  
 Consider the following Lewis structure, where E is an unknown element, which of the following statements is true?



- (A) E 有八個價電子。  
 E has 8 valence electrons.
- (B) E 為 4A 族元素。  
 Element E belongs to Group 4A.
- (C) E 為第四週期或較重的元素。  
 E could be a Row 4 or heavier element.
- (D) 此離子結構呈 T 型，並鍵角約為  $90^\circ$ 。  
 The ion has a T-shaped structure with bond angles of  $\approx 90^\circ$ .
- (E) 此離子結構呈平面三角形，並鍵角約為  $120^\circ$ 。  
 The ion has a plane triangle structure with bond angles of  $\approx 120^\circ$ .

20. P 和 Q 有相同的分子式  $\text{C}_7\text{H}_8\text{O}$ 。以下哪一項描述是正確的？  
 P and Q have the same molecular formula of  $\text{C}_7\text{H}_8\text{O}$ . Which of the following description is correct?



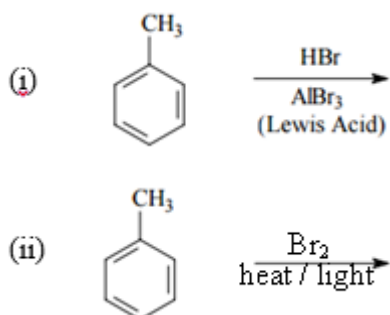
- (A) 兩者都能溶於氫氧化鈉溶液。  
 Both can dissolve in NaOH solution.
- (B) 兩者都能與  $\text{FeCl}_3$  溶液發生反應。  
 Both can react with  $\text{FeCl}_3$  solution.
- (C) 只有 P 可以令  $\text{KMnO}_4$  脫色。  
 Only P can decolorize  $\text{KMnO}_4$ .
- (D) 兩者都對我們的皮膚都有腐蝕性。  
 Both are corrosive to our skin.
- (E) 兩者都可與金屬鈉起反應。  
 Both can react with sodium metal.

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21. 蛋白質最小單位為氨基酸，下列何者是一種氨基酸？  
 Amino acid is the smallest component of protein. Which of the following structures is one type of amino acids?

- (A)  $\text{NH}_2\text{CH}_2\text{CO}_2\text{H}$   
 (B)  $\text{NH}_2\text{CO}_2\text{CH}_2\text{COOH}$   
 (C)  $(\text{CH}_3)_2\text{CHCO}_2\text{NH}_2$   
 (D)  $\text{CH}_3\text{-NH-CH}(\text{CH}_3)\text{CO}_2\text{H}$   
 (E)  $\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$

22. 預測在以下反應條件下會形成的產物（如果有）。  
 Predict products (if any) that would form under the following reaction conditions.



產物 Products:

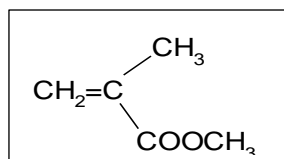
			No product. 無產物。
W	X	Y	Z

- (A) (i): Z (ii): W  
 (B) (i): Z (ii): X  
 (C) (i): X (ii): Z  
 (D) (i): X (ii): W  
 (E) (i): Y (ii): W

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23. 甲基丙烯酸甲酯有以下結構，它的性質包括…

Methyl methacrylate has the following structure. Its properties include.....



- I. 可溶于氫氧化鈉水溶液中。  
It is soluble in aqueous sodium hydroxide solution.
- II. 它能使溴水褪色。  
It can decolorize bromine water.
- III. 它可以由自由基引發劑進行聚合形成聚(甲基丙烯酸甲酯)，是一種重要的透明的塑料，經常被用來作為玻璃的替代品。  
It can be polymerized by free radical initiator to produce poly(methyl methacrylate), an important plastic which is transparent and often used as a glass substitute.
- IV. 它可以通过稀硫酸水解。  
It can be hydrolyzed by dilute sulfuric acid.
- (A) I, III  
(B) II, IV  
(C) I, II, III  
(D) IV  
(E) II, III, IV

24. 以下為四種化合物的鹼性大小排列，何者正確？

The followings are the basicity comparison of four compounds, which one is correct?

- (A)  $\text{NH}_3 > \text{C}_5\text{H}_5\text{N} > \text{H}_2\text{O} > \text{NO}_3^-$   
(B)  $\text{C}_5\text{H}_5\text{N} > \text{NH}_3 > \text{H}_2\text{O} > \text{NO}_3^-$   
(C)  $\text{NH}_3 > \text{C}_5\text{H}_5\text{N} > \text{NO}_3^- > \text{H}_2\text{O}$   
(D)  $\text{C}_5\text{H}_5\text{N} > \text{NH}_3 > \text{NO}_3^- > \text{H}_2\text{O}$   
(E)  $\text{NO}_3^- > \text{NH}_3 > \text{C}_5\text{H}_5\text{N} > \text{H}_2\text{O}$

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25. 以下反應式  $\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons \text{FeSCN}^{2+}(\text{aq})$

以下哪个因素将导致平衡位置向右移动？

Consider the reaction:  $\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons \text{FeSCN}^{2+}(\text{aq})$

Which of the following will cause the equilibrium position shift to the right?

(A) 加入水。

Water is added.

(B) 加入  $\text{AgNO}_3(\text{aq})$ 。

$\text{AgNO}_3(\text{aq})$  is added.

(C) 加入  $\text{NaOH}(\text{aq})$ 。

$\text{NaOH}(\text{aq})$  is added.

(D) 加入  $\text{Fe}(\text{NO}_3)_3$ 。

$\text{Fe}(\text{NO}_3)_3$  is added.

(E) 上述的條件皆不會影響反應平衡。

None of the above will shift the equilibrium position.