

2019 年第 36 屆成大數理比賽 – 化學

下列元素週期表資料供參考

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

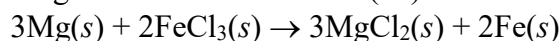
1. 下列何種化合物的名稱與化學式配對是錯誤的？

Which of the following combination of name and formula is incorrect?

- A. H_3PO_4 磷酸 phosphoric acid B. HNO_3 硝酸 nitric acid
 C. $NaHCO_3$ 碳酸鈉 sodium carbonate D. H_2CO_3 碳酸 carbonic acid
 E. KOH 氫氧化鉀 potassium hydroxide

2. 鎂與氯化鐵反應形成氯化鎂和鐵。

Magnesium reacts with iron(III) chloride to form magnesium chloride and iron.



41 g 的鎂和 175 g 的氯化鐵 (III) 反應，請問何者為限量反應物？反應完成後仍殘余多少反應物？

A mixture of 41 g of magnesium and 175 g of iron(III) chloride is allowed to react in the vessel, which is the limiting reactant? After the reaction is completed, how much reactant is left over?

- A. 限量反應物為 Mg，剩下 67 g 的 $FeCl_3$ 。
 Limiting reactant is Mg, 67 g of $FeCl_3$ remains.
 B. 限量反應物為 Mg，剩下 134 g 的 $FeCl_3$ 。
 Limiting reactant is Mg, 134 g of $FeCl_3$ remains.
 C. 限量反應物為 Mg，剩下 104 g 的 $FeCl_3$ 。
 Limiting reactant is Mg, 104 g of $FeCl_3$ remains.
 D. 限量反應物為 $FeCl_3$ ，剩下 2 g 的 Mg。
 Limiting reactant is $FeCl_3$, 2 g of Mg remains.
 E. 限量試劑為 $FeCl_3$ ，剩下 87 g 的 Mg。
 Limiting reactant is $FeCl_3$, 87 g of Mg remains.

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3. 下列何者為氧化還原反應？
Which of the following is a redox reaction?
- A. $2\text{Na}(g) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}(s)$
 - B. $\text{Ba}^{2+}(aq) + \text{SO}_4^{2-}(aq) \rightarrow \text{BaSO}_4(s)$
 - C. $\text{K}_2\text{Cr}_2\text{O}_7(aq) + 2\text{KOH}(aq) \rightarrow 2\text{K}_2\text{CrO}_4(aq) + \text{H}_2\text{O}(l)$
 - D. $\text{Na}_2\text{CO}_3(s) + 2\text{HCl}(aq) \rightarrow 2\text{NaCl}(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l)$
 - E. $\text{H}_2\text{O}(l) \rightarrow \text{H}^+(aq) + \text{OH}^-(aq)$
4. 下列敘述何者不適用於理想氣體？
Which of the following statement is not applicable to an ideal gas?
- A. 氣體分子間沒有吸引力。
There are no attractive forces between the gas molecules.
 - B. 氣體分子間有很強的排斥力。
There are strong repulsive forces between the gas molecules.
 - C. 與容器體積相比，氣體分子佔據的體積可忽略不計。
The volume of the gas molecules is negligible compared to the container volume.
 - D. 氣體運動行為根據理想氣體方程式。
Gas motion behaves according to the ideal gas equation.
 - E. 氣體分子的平均動能和絕對溫度成正比。
The average kinetic energy of the gas molecules is positively proportional to the absolute temperature.
5. 光波被干涉後
Interference of light waves....
- A. 將光分成其組成的顏色。
separates light into its component colors.
 - B. 產生亮區及暗區。
creates a pattern of light and dark regions.
 - C. 將一束光聚焦成一個點。
focuses a broad beam of light into a point.
 - D. 當光線通過物體的邊緣時會彎曲。
bends light as it passes the edge of an object.
 - E. 會產生一束雷射光。
creates a laser beam.

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6. 下列各組有機化合物，哪一對不能由括弧內的試劑做鑒別？
Which pair of organic compounds cannot be differentiated by using the reagent shown in the parenthesis.
- A. 1-丁炔、2-丁炔 (氯化亞銅的氨水溶液)
But-1-yne and but-2-yne (CuCl/NH₃ solution)
 - B. 環己烯、環己烷 (溴的四氯化碳溶液)
Cyclohexene and cyclohexane (Br₂/CCl₄ solution)
 - C. 二甲苯、甲苯 (熱的過錳酸鉀溶液)
Xylene and toluene (hot potassium permanganate solution)
 - D. 正庚烷、甲苯 (熱重鉻酸鉀溶液)
n-Heptane and toluene (hot potassium dichromate solution)
 - E. 丙醛、丙酮 (斐林試劑)
Propanal and acetone (Fehling's reagent)
7. 將銅條、銀條分別置於 1M 的硝酸銅以及 1M 的硝酸銀溶液中，其中兩金屬條以導線連接伏特計，並以鹽橋連接兩溶液。以下為其標準還原電位：
A strip of copper is placed in a 1 M solution of copper nitrate, and a strip of silver is placed in a 1 M solution of silver nitrate. The two metal strips are connected to a voltmeter by wires, and a salt bridge connects the solutions. The following standard reduction potentials apply:
- $$\text{Ag}^+(aq) + e^- \rightarrow \text{Ag}(s) \quad E^\circ = +0.80 \text{ V}$$
- $$\text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s) \quad E^\circ = +0.34 \text{ V}$$
- 伏特計移除時(兩金屬條依然以導線連接)，以下哪個敘述不可能發生？
When the voltmeter is removed and the two electrodes are connected by a wire, which of the following does not take place?
- A. 負離子由銀半電池經由鹽橋移動至銅半電池。
Negative ions pass through the salt bridge from the silver half-cell to the copper half-cell.
 - B. 當反應發生時銀電極會變重。
The silver electrode increases in mass as the cell operates.
 - C. 在外部線圈中，電子流會由銅電極流至銀電極。
Electrons flow in the external circuit from the copper electrode to the silver electrode.
 - D. 部分銅正離子經由鹽橋移動至銀半電池。
Some positive copper ions pass through the salt bridge from the copper half-cell to the silver half-cell.
 - E. 銀離子會經由鹽橋移動至銅半電池。
There is a net general movement of silver ions through the salt bridge to the copper half-cell.

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8. 量子力學發展出的原子軌域....
Atomic orbitals developed using quantum mechanics.....
- A. 描述電子出現在空間中的最大機率。
describe regions of space in which one is most likely to find an electron.
 - B. 描述電子運動的確切路徑。
describe exact paths for electron motion.
 - C. 描述原子結構基本上與玻爾模型相同。
give a description of the atomic structure which is essentially the same as the Bohr model.
 - D. 讓科學家能夠計算出氫原子的真實體積。
allow scientists to calculate an exact volume for the hydrogen atom.
 - E. 和海森堡測不準原理相互抵觸。
are in conflict with the Heisenberg Uncertainty Principle.
9. 當強碱滴定弱酸時，其當量點的 pH 值
When a weak acid is titrated with a strong base, the pH at the equivalence point
- A. 大於 7.0。
is greater than 7.0.
 - B. 等於 7.0。
is equal to 7.0.
 - C. 小於 7.0。
is less than 7.0.
 - D. 等於此弱酸的 pK_a 。
is equal to the pK_a of the acid.
 - E. 以上皆非。None of the above.
10. 下列離子之半徑大小順序何者正確？
Which of following is the correct order of decreasing ion size?
- A. $P^{3-} > Cl^- > K^+ > Ca^{2+}$
 - B. $Ca^{2+} > K^+ > Cl^- > P^{3-}$
 - C. $K^+ > Cl^- > Ca^{2+} > P^{3-}$
 - D. $K^+ > Cl^- > P^{3-} > Ca^{2+}$
 - E. 以上皆非。None of the above.
11. 在水中加入 NaOH 後，可提升下列何者之水溶性？
Which of the following becomes more soluble in water upon the addition of NaOH?
- A. 烷烴 alkane
 - B. 芳香烴 aromatic hydrocarbon
 - C. 胺 amine
 - D. 羧酸 carboxylic acid
 - E. 醯胺 amide

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12. COCl_2 分子中，碳為中心原子。根據路易斯結構， COCl_2 之碳原子的形式電位為多少？
In the COCl_2 molecule, carbon is the central atom. Based on the best Lewis structure for COCl_2 , what is the formal charge on carbon?
- A. 0 B. +1 C. -1 D. +2 E. -2
13. 下列何種物質在水中有最大的溶解度？
Which of the following substance has the greatest solubility in water?
- A. PbI_2 , $K_{\text{sp}} = 7.9 \times 10^{-9}$
B. BaF_2 , $K_{\text{sp}} = 1.5 \times 10^{-6}$
C. $\text{Ca}(\text{OH})_2$, $K_{\text{sp}} = 6.5 \times 10^{-6}$
D. $\text{Zn}(\text{IO}_3)_2$, $K_{\text{sp}} = 3.9 \times 10^{-6}$
E. Ag_2SO_4 , $K_{\text{sp}} = 1.5 \times 10^{-5}$
14. 如何配置體積為 1.00 L，濃度為 2.0 M 的尿素溶液？尿素分子量為 60.06 g/mol。
Which of the following statement describes the correct method to prepare 1.00 L of 2.0 M urea solution? The molecular weight of urea is 60.06 g/mol.
- A. 將 120 g 的尿素溶解在 1.00 kg 的蒸餾水中。
Dissolving 120 g of urea in 1.00 kg of distilled water.
- B. 將 120 g 的尿素溶解在 880g 的蒸餾水中。
Dissolving 120 g of urea in 880 g of distilled water.
- C. 將 120 g 的尿素溶解在足夠的蒸餾水中並配置成 1.00 L 的溶液。
Dissolving 120 g of urea in enough distilled water to produce 1.00 L of solution.
- D. 將 120 g 的尿素溶解在 1.00 L 的蒸餾水中。
Dissolving 120 g of urea in 1.00 L of distilled water.
- E. 需要尿素的密度才能計算。
The density of urea is needed in order to do this calculation.
15. 下列何者為共軛酸鹼對(前者為酸，後者為其共軛鹼)？
Select the pair of substances in which an acid is listed followed by its conjugate base.
- A. H^+ , HCl
B. NH_3 , NH_4^+
C. HPO_4^{2-} , H_2PO_4^-
D. HCO_3^- , CO_3^{2-}
E. CH_3COOH , $\text{CH}_3\text{COOH}_2^+$

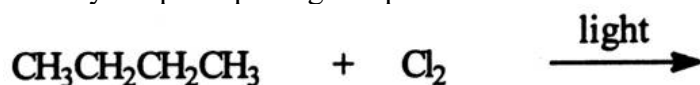
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16. 下列哪一個屬於乙烷和乙烯的不同點？
What is the difference between ethane and ethylene?

(I) 乙烷只含有碳和氫元素。Ethane contains only carbon and hydrogen element.
 (II) 它們屬於不同族體系列。They belong to different homologous series.
 (III) 乙烯燃燒產生二氧化碳和水。Ethylene burns to form carbon dioxide and water.
 (IV) 乙烯能跟溴水起反應。Ethylene can react with bromine water.

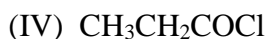
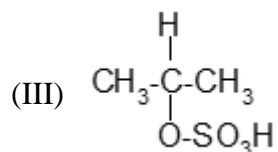
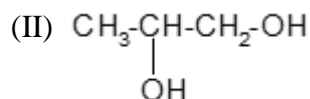
- A. I, II, III B. I, III C. II, IV
 D. IV E. 以上皆非。None of the above.

17. 丁烷和氯氣反應的主要有機產物為何？
Identify the principal organic product of the reaction between butane and chlorine.



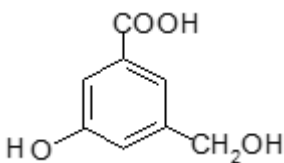
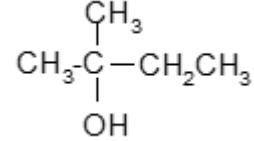
- A. CH_3Cl
 B. $\text{CH}_3\text{CH}_2\text{CHClCH}_3$
 C. $\text{CH}_3\text{CHClCH}_3$
 D. $\text{CH}_3\text{CH}_2\text{Cl}$
 E. 以上皆非。None of the above.

18. 下列哪一些有機化合物可與鈉金屬起反應而釋放氫氣？
Which of the following organic compound can react with sodium metal to release hydrogen gas?



- A. I, II, III B. I, III C. II, IV
 D. IV E. 以上皆非。None of the above.

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19. 下列選項何者會影響平衡常數的大小？
Which of the following has an effect on the magnitude of the equilibrium constant?
- A. 加入催化劑。
adding a catalyst.
 - B. 加入較多反應物。
adding more reactant.
 - C. 移除生成的產物。
removing products as they are formed.
 - D. 氣相反應中，增加壓力。
increasing the pressure in a gas-phase reaction.
 - E. 改變溫度。
changing the temperature.
20. 下列哪一化合物可以與 PCl_5 起反應釋放氯化氫，而且能與冷的 KMnO_4 溶液起反應？
Which of the organic compound can react with PCl_5 to release hydrogen chloride and also react with cold KMnO_4 solution?
- (I) $\text{CH}_2(\text{OH})\text{CH}_2\text{CH}_2\text{COOH}$ (II) $\text{CH}_3\text{CH}_2\text{CH}_2\text{-O-CH}_2\text{CH}_3$
- (III)  (IV) 
- A. I, II, III B. I, III C. II, IV
D. IV E. 以上皆非。 None of the above.
21. 醋酸鹽緩沖溶液的 pH 值為 4.40，下列何種變化可以使 pH 值上升？
An acetate buffer has a pH of 4.40. Which of the following change will cause the pH to rise?
- A. 加入少量的醋酸鈉晶體。
Adding a small amount of solid sodium acetate.
 - B. 加入少量的稀鹽酸溶液。
Adding a small amount of dilute hydrochloric acid.
 - C. 加入少量的氫氧化鈉溶液。
Adding a small amount of dilute sodium hydroxide.
 - D. 加入少量的氯化鈉晶體。
Adding a small amount of solid sodium chloride.
 - E. 用水稀釋此緩沖溶液。
Diluting the buffer solution with water.

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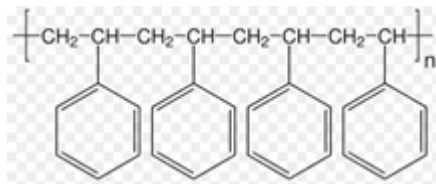
22. 根據以下資訊，試問 $A \rightarrow 2C + E$ 之 ΔH 為多少？

Consider the following processes:



ΔH for the process $A \rightarrow 2C + E$ is:

- (A) $\Delta H_1 + \Delta H_2 + \Delta H_3$
(B) $\Delta H_1 + \Delta H_2$
(C) $\Delta H_1 + \Delta H_2 - \Delta H_3$
(D) $\Delta H_1 + 2\Delta H_2 - \Delta H_3$
(E) $\Delta H_1 + 2\Delta H_2 + \Delta H_3$
23. 下列何者為二級反應速率常數的單位？
Which one of the following unit is correct for a second-order rate constant?
- A. s^{-1} B. $\text{mol L}^{-1} s^{-1}$ C. $\text{L mol}^{-1} s^{-1}$ D. $\text{mol}^2 \text{L}^{-2} s^{-1}$ E. $\text{L}^2 \text{mol}^{-2} s^{-1}$
24. 以下的構造代表某聚合物分子的一部分。下列各項有關該聚合物的說法，那一些是不正確的？
The below structure represents part of a polymer. Which of the following statement about the polymer is not correct?



- (I) 它的名字是聚苯乙烯。 Its name is polystyrene.
(II) 它的重覆單元是苯乙烯。 The repeating unit is styrene.
(III) 它是一種熱塑塑料。 It is a thermoplastic.
(IV) 它的分子量是 104。 The molecular weight is 104.

A. I, II, III
D. IV

B. I, III

C. II, IV

E. 以上皆非。 None of the above.

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25. 同位素 ${}^{42}_{21}\text{Sc}$ 不穩定，因為
The isotope ${}^{42}_{21}\text{Sc}$ is unstable because
- A. 相對於質子的數量，中子的數量太多。
the number of neutrons is too large in relation to the number of protons.
 - B. 相對於質子的數量，中子的數量太少。
the number of neutrons is too small in relation to the number of protons.
 - C. 原子序數太大。
the atomic number is too large.
 - D. 質量數太大。
the mass number is too large.
 - E. Sc 的所有同位素都不穩定
all isotopes of Sc are unstable.