



馬來西亞留台成功大學校友會

主 辦

2025 年

第四十屆成大數理比賽

考生指示：

- (一) 解答所有問題。
- (二) 將正確答案在答案紙上的圓圈內“塗黑”，每題只准給一個答案。
- (三) 正確的答案得三分，錯誤的答案扣一分，不做答的零分。

INSTRUCTIONS TO CANDIDATES

1. Attempt all questions.
2. Pick the correct answer and make a mark “●” in the circle provided in the answer sheet. Only one answer is allowed for each question.
3. Three marks for a correct answer, one mark will be deducted for each wrong answer. No mark will be given to each question not attempted.

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1. Which of the following reagents can be used to convert butanol into a carboxylic acid?

下列哪一種試劑可用於將丁醇化為羧酸？

(I) HCOOH (II) PCl_3 (III) $\text{KMnO}_4 (\text{H}^+)$ (IV) HCl/Zn

(A) I, II, III

(B) II, IV

(C) I, III

(D) III

(E) None of the above 以上都不是

2. Let the first ionization energies of Na, Mg, and Al be a, b, and c kJ/mol respectively, the second ionization energies be d, e, and f, and the third ionization energies be g, h, and i. Which of the following shows the correct order of these 9 values from the highest to the lowest ionization energies?

若 Na、Mg、Al 的第一游離能依序為 a、b、c kJ/mol，第二游離能依序為 d、e、f kJ/mol，第三游離能依序為 g、h、i kJ/mol，將此 9 個能量由大至小排列為下列何者？

(A) $b > c > a > i > f > e > h > g > d$ (B) $h > g > d > e > f > i > b > c > a$ (C) $a > c > b > e > f > i > d > g > h$

(D) $d > g > h > i > f > e > b > c > a$ (E) $h > g > d > i > f > e > b > c > a$

3. The following solutions were mixed in a same container: 25 mL of 0.02 M NaI, 25 mL of 0.01 M NaBr, 25 mL of 0.03 M NaCl, and 25 mL of 0.05 M AgNO_3 . What would be the concentration of $[\text{I}^-]$ at equilibrium? (Given that the K_{sp} values of AgCl, AgBr, and AgI are 1.8×10^{-10} , 5.0×10^{-13} , and 1.0×10^{-16} , respectively.)

將下列溶液混合在同一容器中：0.02 M NaI 25 mL、0.01 M NaBr 25 mL、0.03 M NaCl 25 mL 及 0.05 M AgNO_3 25 mL。則平衡時 $[\text{I}^-]$ 為多少 M？(已知 AgCl、AgBr、AgI 的 K_{sp} 依次為 1.8×10^{-10} 、 5.0×10^{-13} 、 1.0×10^{-16} 。)

(A) 1.4×10^{-7} (B) 2.8×10^{-7} (C) 1.4×10^{-9} (D) 2.8×10^{-9} (E) 1.4×10^{-11}

4. Which of the following compounds is NOT an aromatic compound?

下列哪一種化合物不是芳香族化合物？

(A) Pyridine 吡啶

(B) Cyclopentadienyl anion 環戊二烯基陰離子

(C) Cycloheptatriene 環庚三烯

(D) Thiophene 噻吩

(E) Toluene 甲苯

5. What is the correct order of boiling points from the highest to the lowest among CH_4 , NH_3 , H_2O , and HF?

試問 CH_4 、 NH_3 、 H_2O 、HF 四個分子的沸點由高至低的排列順序為何？

(A) $\text{CH}_4 > \text{NH}_3 > \text{HF} > \text{H}_2\text{O}$ (B) $\text{CH}_4 > \text{NH}_3 > \text{H}_2\text{O} > \text{HF}$ (C) $\text{H}_2\text{O} > \text{NH}_3 > \text{HF} > \text{CH}_4$

(D) $\text{H}_2\text{O} > \text{HF} > \text{NH}_3 > \text{CH}_4$ (E) $\text{CH}_4 > \text{HF} > \text{H}_2\text{O} > \text{NH}_3$

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6. For the reaction $2A(g) + B(g) \rightarrow C(g)$, the rate law is given by $r = k[A]^2[B]$. In a container where the volume is fixed, if A and B are mixed in equal molar amounts, the initial reaction rate is measured as R. If the molar ratio of A to B is changed to 1:2 while maintaining constant temperature and pressure, what will the new reaction rate be in terms of R?

反應 $2A(g) + B(g) \rightarrow C(g)$ 其反應速率式為 $r = k[A]^2[B]$ 。於體積是固定的容器中，若取 A、B 以等莫耳數相混合，測得其最初的反應速率為 R。若改以 A、B 莫耳數比為 1:2 比例混合，在溫度和壓力不變下，其反應速率將變為多少 R？

(A) 4/9 (B) 9/4 (C) 12/18 (D) 27/16 (E) 16/27

7. Which of the following greenhouse gases has the highest global warming potential (GWP) over a 100-year time horizon?

下列哪一種溫室氣體在 100 年的時間範圍內具有最高的全球暖化潛勢？

- A) Carbon dioxide 二氧化碳 (CO_2)
- B) Methane 甲烷 (CH_4)
- C) Nitrous oxide 笑氣 (N_2O)
- D) Sulfur hexafluoride 六氟化硫 (SF_6)
- E) Benzene 苯 (C_6H_6)

8. Which of the following commercial applications primarily utilizes polyethylene terephthalate (PET) due to its excellent barrier properties, transparency, and recyclability?

由於聚對苯二甲酸乙二醇酯 (PET) 具有優異的阻隔性、透明度和可回收性，下列哪一種商業應用主要利用該材料？

- (I) Car tires 汽車輪胎
- (II) Food packaging 食品包裝
- (III) Thermal insulation foams 隔熱泡沫
- (IV) Beverage packaging 飲料包裝

(A) I, II, III

(B) II, IV

(C) I, III

(D) III

(E) None of the above 以上都不是

9. How many isomers of C_5H_{10} are alkenes?

試問 C_5H_{10} 之異構物中屬於烯類的共有幾種？

(A) 5 (B) 6 (C) 7 (D) 8 (E) 9

10. To prepare a buffer solution with a pH of 5.7 using a weak acid (HX) and its sodium salt (NaX), where the pH of a 0.20 M NaX solution is 10, what is the closest ratio of [NaX] to [HX] in the buffer solution?

有一單質子弱酸(HX)的鈉鹽(NaX)，已知 0.20 M 的 NaX 溶液之 pH 值為 10。現擬以 HX 和 NaX 混合配製 pH 值為 5.7 的緩衝溶液，則此緩衝溶液中 [NaX] / [HX] 的比值最接近下列哪一數字？

(A) 0.1 (B) 0.2 (C) 0.5 (D) 1.0 (E) 10

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11. Which of the following commercial applications is NOT typically associated with natural rubber?

下列哪一種商業應用通常與天然橡膠無關？

- (I) Automotive tire 汽車輪胎 (II) Medical gloves 醫用手套
(III) Packaging furniture 包裝家具 (IV) Surgical tubing 手術導管

(A) I, II, III

(B) II, IV

(C) I, III

(D) III

(E) None of the above 以上都不是

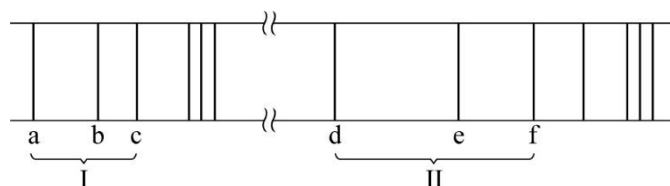
12. There are three interconnected glass spheres X, Y, and Z, with gas flow between them controlled by valves. It is known that the volume of each sphere is 1.0 L, and the volume of the connecting pipes is negligible. In an isothermal environment, 0.9 atm of COCl_2 is placed in X, 0.3 atm of Cl_2 in Y, and 0.3 atm of CO in Z. It is also known that phosgene (COCl_2) easily decomposes into carbon monoxide (CO) and chlorine (Cl_2), with the equilibrium constant for this reaction, $K_p = 0.2$ (atm). Calculate the total pressure of the system after the valves are opened and equilibrium is reached. (*Assuming no change of temperature*)

有三個互相連通的玻璃球 X、Y、Z，球間以開關閥控制其氣體流動。已知三球體積皆為 1.0 L 且忽略連通管的體積。若在等溫環境下於三球中放入 X：0.9 atm 的 COCl_2 、Y：0.3 atm 的 Cl_2 、Z：0.3 atm 的 CO，且已知光氣(COCl_2)容易分解成一氧化碳(CO)與氯氣(Cl_2)，其反應之平衡常數 $K_p = 0.2(\text{atm})$ ，請計算在打開閥並達平衡後，系統的總壓為多少 atm？(假設溫度不變)

- (A) 0.6 (B) 0.7 (C) 0.8 (D) 0.9 (E) 1.0

13. The diagram shows the spectral lines in the ultraviolet and visible light regions of the hydrogen atom spectrum. Which of the following statements is correct?

附圖為氫原子光譜中紫外光區及可見光區的譜線圖，下列敘述何者正確？



- (A) The Lyman series is in the I region.

來曼譜系是 I 區

- (B) The transition of the hydrogen atom's electron from $n = 4$ to $n = 3$ produces the e spectral line.

氫原子的電子由 $n = 4$ 降至 $n = 3$ 是 e 譜線

- (C) The transition of the hydrogen atom's electron from $n = 4$ to $n = 2$ produces the c spectral line.

氫原子的電子由 $n = 4$ 降至 $n = 2$ 是 c 譜線

- (D) The frequency ratio of the e and d spectral lines is 32:27.

譜線 e 與 d 的頻率比 = 32 : 27

- (E) The wavelength ratio of the d and b spectral lines is 4:1.

譜線 d 與 b 的波長比 = 4 : 1

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14. Assume that all the oxygen in KClO_3 can be converted into O_2 . How many liters of oxygen, in its wet form, can be collected using the water displacement method when 245 grams of KClO_3 is decomposed at 27°C and 1.00 atm pressure? (Assume the water levels inside and outside the gas collection bottle are the same, and the vapor pressure of water at 27°C is 27 mmHg. Molar mass of $\text{KClO}_3 = 122.5 \text{ g/mol}$.)

假設 KClO_3 中之所有氧都可以轉變成 O_2 ，試問用 245 克 KClO_3 製備氧時，在 27°C 和 1.00 atm 大氣壓下，用排水集氣法可收集到未經乾燥的氧多少升？(設集氣瓶內外液面等高， 27°C 時之水蒸氣壓力為 27 mmHg， KClO_3 的分子量 = 122.5 g/mol)

(A) 25.3 (B) 100.5 (C) 153.0 (D) 38.3 (E) 76.5

15. Which of the following molecules require electron promotion followed by orbital hybridization in order to form bonds?

試問下列哪些分子在形成鍵結時，須先進行電子提升，再進行軌域混成？

(A) OF_2 (B) NH_3 (C) H_2O (D) BeF_2 (E) All of the above are required. 以上皆需要

16. 3.57 grams of CoCO_3 is heated and decomposed in a vacuum. After complete decomposition, it produces a cobalt oxide I weighing 2.25 grams. The oxide I is then placed in air, where it absorbs oxygen from the air, forming another cobalt oxide II weighing 2.41 grams. Which of the following statements is correct? (atomic mass of Co = 59)

將 3.57 克 CoCO_3 在真空中加熱分解，完全分解後產生一種鈷的氧化物 I 為 2.25 克，將 I 放置於空氣中吸收空氣中的氧氣，將生成鈷的另一氧化物 II 為 2.41 克，試問下列敘述何者正確？(Co 的分子量 = 59)

(A) The chemical formula of I is Co_2O_3

I 的化學式為 Co_2O_3

(B) The chemical formula of II is Co_3O_4

II 的化學式為 Co_3O_4

(C) Compound I contains 0.01 mole of Co atoms

I 中含 Co 原子 0.01 莫耳

(D) Compound II contains 0.03 mole of oxygen atoms

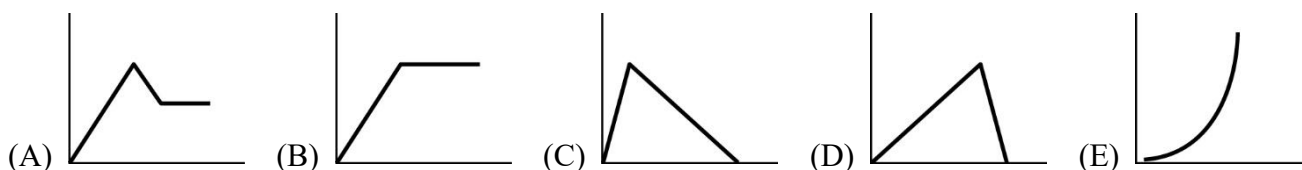
II 中含氧原子 0.03 莫耳

(E) The number of Co atoms in compounds I and II is different

I 與 II 中 Co 原子個數不同

17. When 1M $\text{NaOH}(\text{aq})$ is added drop by drop to 1M $\text{Al}(\text{NO}_3)_3(\text{aq})$, if the amount of $\text{NaOH}(\text{aq})$ added is plotted on the x-axis and the amount of precipitate produced is plotted on the y-axis, which of the following graphs best represents the situation?

在 1M $\text{Al}(\text{NO}_3)_3(\text{aq})$ 中逐滴加入 1M $\text{NaOH}(\text{aq})$ ，若以所加入 $\text{NaOH}(\text{aq})$ 的量為橫坐標，產物沉澱量為縱坐標，試從下列選項中選出最適合的圖形。



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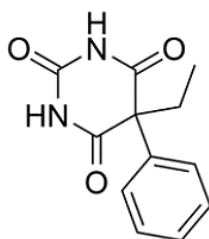
18. Which of the following is the main component of enzymes?

下列何者是酵素最主要的成分？

- (A) Carbohydrates 醣類
(B) Proteins 蛋白質
(C) Fats 脂肪
(D) Ribonucleic acid 核糖核酸
(E) Minerals 礦物質

19. The structure of phenobarbital is shown in the figure. How many carbon atoms in this molecule have sp^2 hybridized orbitals?

苯巴比妥其結構式如圖，則此分子中具有 sp^2 混成軌域的碳原子共有多少個？



- (A) 5 (B) 6 (C) 7 (D) 8 (E) 9

20. ABS engineering rubber is made by copolymerizing three monomers—acrylonitrile, 1,3-butadiene, and styrene—in a certain ratio. After electroplating treatment, it is commonly used as the outer shell or knob of electrical products. Now, a certain ABS sample has been analyzed by elemental analysis and its empirical formula is $C_{21}H_{22}N$. Please calculate the simplest mole ratio (acrylonitrile: 1,3-butadiene: styrene) in this sample.

ABS 工程橡膠是由丙烯腈、1,3-丁二烯及苯乙烯三種單體依一定比例共聚而成，經電鍍處理後，常作為電器產品的外殼或旋鈕。現有某一 ABS 樣品，經由元素分析得知其實驗式為 $C_{21}H_{22}N$ ；試推算此樣品中丙烯腈、1,3-丁二烯、苯乙烯三者的最簡單混合莫耳數比(丙烯腈：1,3-丁二烯：苯乙烯)為何？

- (A) 2 : 1 : 4 (B) 1 : 2 : 4 (C) 1 : 1 : 1 (D) 4 : 1 : 2 (E) 4 : 2 : 1

21. In a Na_3PO_4 aqueous solution, when HCl gas is passed through it, and the $pH = 4$, which species has the highest concentration in the solution? (K_{a1} of $H_3PO_4 = 7.1 \times 10^{-3}$, $K_{a2} = 6.3 \times 10^{-8}$, $K_{a3} = 4.4 \times 10^{-13}$)

在 Na_3PO_4 的水溶液中，通入 HCl 氣體，當 $pH = 4$ 時，則溶液中何種粒子的濃度最大？(H_3PO_4 之 $K_{a1} = 7.1 \times 10^{-3}$ 、 $K_{a2} = 6.3 \times 10^{-8}$ 、 $K_{a3} = 4.4 \times 10^{-13}$)

- (A) H_3PO_4 (B) $H_2PO_4^-$ (C) HPO_4^{2-} (D) PO_4^{3-} (E) The concentrations of the four species are all the same
以上四個物種濃度皆相同

22. Which of the following aqueous solutions, when electrolyzed, will produce $O_2(g)$ at the anode and $H_2(g)$ at the cathode, and the pH of the solution will increase after electrolysis?

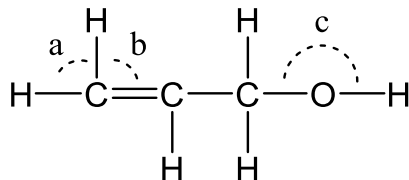
電解下列何種水溶液，陽極可得 $O_2(g)$ ，而陰極可得 $H_2(g)$ ，且電解後溶液的 pH 值上升？

- (A) $H_2SO_4(aq)$ (B) $NaCl(aq)$ (C) $KOH(aq)$ (D) $AgNO_3(aq)$ (E) $K_2SO_4(aq)$

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23. Allyl alcohol is an organic compound used as an intermediate in the production of glycerol, pharmaceuticals, pesticides, fragrances, and cosmetics. Its structural formula is shown below, where a, b, and c represent the bond angles of H-C-H, H-C=C, and C-O-H, respectively. *Note that this structural formula does not show the actual bond angles.* Which of the following is the correct order of bond angles a, b, and c from the largest to the smallest?

丙烯醇是一種有機物，用於生產甘油、醫藥、農藥、香料和化妝品的中間體，其結構式如附圖，其中 a、b、c 各為 H-C-H、H-C=C、C-O-H 之鍵角，注意此結構式並未依照實際構形角度畫圖，試問圖中 a、b、c 三個鍵角由大至小排列何者正確？



- (A) $a > b > c$ (B) $b > a > c$ (C) $c > a > b$ (D) $c > b > a$ (E) $b > c > a$

24. Reaction $A(g) \rightarrow B(g) + 2C(g)$. The experimental data for the concentration of A(g) as it changes over time is shown in the table below. Please calculate the rate constant.

反應 $A(g) \rightarrow B(g) + 2C(g)$ ，A(g) 的濃度隨時間變化的實驗數據如下表，試求速率常數為多少？

Time(s)	0	10	20	30
[A](M)	1.28	1.04	0.80	0.56

- (A) $0.024 \text{ M}^{-1} \cdot \text{s}^{-1}$ (B) 0.048 s^{-1} (C) 0.024 s^{-1} (D) $0.048 \text{ M} \cdot \text{s}^{-1}$ (E) $0.024 \text{ M} \cdot \text{s}^{-1}$

25. Ozone is a polar molecule. Which of the following statements about ozone and oxygen is correct?

臭氧為極性分子，下列有關臭氧與氧氣的敘述，何者正確？

- (A) Both ozone and oxygen molecules are linear.

臭氧與氧氣分子均為直線形

- (B) The normal boiling point of ozone is lower than the normal boiling point of oxygen.

臭氧的正常沸點低於氧氣的正常沸點

- (C) In the gaseous state, under the same temperature and pressure, the density of ozone is greater than that of oxygen.

在氣態時，同溫、同壓下，臭氧的比重大於氧氣的比重

- (D) Both ozone and oxygen can turn iodide-starch paper blue.

臭氧與氧氣均可使碘化鉀-澱粉試紙變為藍色

- (E) Ozone is an isotope of oxygen.

臭氧是氧氣的同位素

END OF PAPER