

# 中央警察大學 110 學年度碩士班入學考試試題

所 別：鑑識科學研究所

科 目：自然科學

作答注意事項：

- 1.本試題共 10 題，每題各占 10 分；共 2 頁。
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一、將下列運算結果以適當之有效位數表示：

(一)  $2.35+0.576+8.0021$

(二)  $15000-80$

(三)  $3.76\times 4.555$

(四)  $10.622\div 2.0$

(五)  $(0.45\times 10.66)+15.88$

二、完成下列反應之平衡方程式：

(一) 乙醇與酸性重鉻酸鉀

(二) 汽車引擎不完全燃燒（以辛烷表示）

三、物體受熱導致膨脹，與溫度的變化息息相關，請回答下列有關溫標與溫度變化之問題：

(一) 請計算攝氏溫標與華氏溫標在哪個溫度下二者相同？

(二) 若某金屬尺之線膨脹係數  $\alpha=2.0\times 10^{-5}/^{\circ}\text{C}$ ，若該金屬尺在常溫下（ $25^{\circ}\text{C}$ ）長度為 2.5000 公尺，則在夏天豔陽高照（ $42^{\circ}\text{C}$ ）下，計算該金屬尺之長度？

- 四、一行人以 7.0 m/s 之速率追趕一輛公車，當他距離該公車 20m 處時，公車以 1.0 m/s<sup>2</sup> 的等加速度駛離，請計算並作距離－時間圖，說明該行人有無可能追上該公車？
- 五、請以色胺酸操作組 (*trp* Operon) 為例，說明原核生物基因表現之調節？
- 六、Please write the balanced equation, total ionic equation and net ionic equations for the precipitation of magnesium phosphate from the addition of a magnesium nitrate solution to a sodium phosphate solution.
- 七、The spring constant between the oxygen atoms in <sup>16</sup>O<sub>2</sub> is around 1180 N/m. Calculate the angular frequency and the vibrational frequency of O<sub>2</sub> molecule.

$$\omega_{\text{oscillator}} = 2\pi\nu_{\text{oscillator}} \quad \omega_{\text{oscillator}} = \sqrt{\frac{k}{\mu}}$$

- 八、When photons interact with molecules, two types of scattering can occur, please define these scatterings in detail and describe where you can observe them in nature.
- 九、Why does a solution containing a greater amount of Yellow Dye No. 5 appear darker yellow than a solution that contains a smaller amount of the dye?
- 十、Why are the calculations of frequencies of genotypes or DNA profiles based on the Hardy-Weinberg principle likely to be underestimated?

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一、請依據孟德爾 (G. J. Mendel) 提出之獨立分配律 (Law of independent assortment)，說明不同人之間 DNA 多樣性的產生；依此說明並請計算一對夫妻可能生下幾種 DNA 不同的孩子。

二、穩定同位素具有鑑別相關檢體產地來源之潛力，因此，在刑事鑑識上亦有其應用之價值。請說明何謂同位素 (Isotopes)？並請以質量數為 24、25 及 26 之鎂原子為例，分別說明其質子數與中子數。

三、某鑑識實驗室發展了一個血液鑑定系統，為了解此系統在進行偵測時需要的血液量，故進行下列的實驗：取 10  $\mu\text{L}$  的血液進行一連串的十倍稀釋，並從 10 倍、100 倍及 1,000 倍稀釋液中，分別取 10  $\mu\text{L}$  去進行測試。請說明如何由 10  $\mu\text{L}$  的血液進行一連串的十倍稀釋至 1,000 倍；並請計算 10  $\mu\text{L}$  之 10 倍、100 倍及 1,000 倍稀釋液中分別含多少量之血液。

四、臺鐵的某一火車由 A 站從靜止狀態出發，然後以等加速度直線往 B 站行駛，10 秒後之速率達 40 公尺 / 秒，請計算加速度；此時距離 A 站有多少公尺？再繼續往前開 88 公尺後，其速率為多少？(需列出計算過程)

五、某案件之檢體裂解嚴重，使得細胞核 DNA 之鑑定失敗，鑑識人員遂改以鑑定粒線體 DNA，請說明其原因。

六、 The spring constant between the atoms in HBr is around 412 N/m. Determine the energy difference between the  $n = 0$  and  $n = 1$  states for this molecule in joules. What photon wavelength, in units of microns, and wave number, would be associated with absorption from  $n = 0$  to  $n = 1$ ? Where in the electromagnetic spectrum is this absorption?

$$\omega_{oscillator} = \sqrt{\frac{k}{\mu}} = \sqrt{\frac{k}{\frac{m_1 m_2}{m_1 + m_2}}}$$

$$\nu_{oscillator} = \frac{\omega_{oscillator}}{2\pi}$$

七、 Snells law :  $n_1 \sin \theta_1 = n_2 \sin \theta_2$

A broadband light source is composed of wavelengths from 400 nm to 800 nm. The beam is incident on a block of BK7 glass at an angle of 30.0 degrees from the normal. What happens to the beam as it refracts through the glass? Answer this quantitatively by describing the refraction of the 400 nm and 800 nm extremes in wavelength.

八、 Write a Lewis structure and identify the octet-rule exception for

(a) XeF<sub>4</sub>;

(b) H<sub>3</sub>PO<sub>4</sub> (draw two resonance structures and select the more important; all O atoms are bonded to P and three O atoms have H bonded to them);

(c) BFCl<sub>2</sub>

九、 At 1000°C, cyclobutane (C<sub>4</sub>H<sub>8</sub>) decomposes in a first-order reaction, with the very high rate constant of 87 s<sup>-1</sup>, to two molecules of ethylene (C<sub>2</sub>H<sub>4</sub>).

(a) The initial C<sub>4</sub>H<sub>8</sub> concentration is 2.00 M. What is the concentration after 0.010 s?

(b) How long will it take for 70.0% of the C<sub>4</sub>H<sub>8</sub> to decompose?

十、 Which type of polymer is formed from each of the following monomers:

(a) amino acids; (b) alkenes; (c) simple sugars; (d) mononucleotides?

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一、請說明細胞中哪些類別的基因遭突變較容易形成癌症 (cancer)？  
癌細胞具有哪些特性？

二、針對蛋白質在細胞膜上所扮演之功能，請說明主要有哪些分類？

三、請計算 50 mM 的醋酸溶液於 2.7、4.7 及 5.7 等 3 種不同 pH 值時，  
其醋酸離子 ( $\text{CH}_3\text{COO}^-$ ) 及醋酸 ( $\text{CH}_3\text{COOH}$ ) 於溶液中之濃度各  
為多少？(請列出其計算流程，濃度以 mM 表示，並計算至小數點  
第 3 位，假設醋酸的 pKa 為 4.7)

四、請繪出下列各種異構物的結構：

- (一) open-chain form of D-glucose
- (二) open-chain form of D-fructose
- (三)  $\alpha$ -D-glucopyranose
- (四)  $\alpha$ -D-fructopyranose
- (五)  $\beta$ -D-fructofuranose

五、請簡要繪出 Transmission electron microscope (TEM) 及 Scanning  
electron microscope (SEM) 之結構圖，並說明其呈像原理之差異。

六、Suppose a motor drives a block on a spring at a frequency  $\omega$ , and the  
natural frequency of the spring-block system is  $\omega_0$ . If damping is

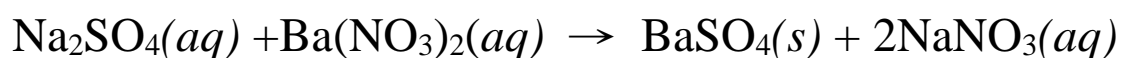
negligible, by what factor does the amplitude of oscillation change when the driving frequency is increased from  $\omega = 2\omega_0$  to  $\omega = 3\omega_0$ ?

- 七、A person standing in the middle of a long straight road sees a truck with its headlights on approaching in the distance. The truck's headlights are 3 m apart. Assuming the headlights are point sources emitting yellow light of wave-length 600 nm and the diameter of the human pupil is 5 mm, approximately how far is the truck from the person when he can first resolve the two headlights as separate sources?
- 八、Automobile airbags inflate when sodium azide ( $\text{NaN}_3$ ) contained in the bags explodes during a collision. Calculate the volume of gas produced at STP conditions if 32.5 g of sodium azide are used to inflate a side-impact airbag according to the following equation:



Molar mass of  $\text{NaN}_3 = 65.01 \text{ g/mol}$

- 九、The tampered bottle of Coke was analyzed for the presence of sulfate ion by adding barium nitrate to trigger the precipitation of barium sulfate. Determine the limiting reagent and the theoretical yield of barium sulfate given that a solution containing 1.60 g of sodium sulfate is mixed with a solution containing 2.40 g of barium nitrate.



Molar mass of  $\text{Na}_2\text{SO}_4 = 142.05 \text{ g/mol}$

Molar mass of  $\text{Ba}(\text{NO}_3)_2 = 261.34 \text{ g/mol}$

- 十、Xeroderma pigmentosum (XP) is a rare genetic disorder characterized by an extreme sensitivity to ultraviolet (UV) radiation. Individuals with XP have a reduced ability to repair DNA damage caused by UV light, which leads to an increased risk of skin cancer and various other skin abnormalities. What molecular lesion is most likely to accrue in individuals with XP?

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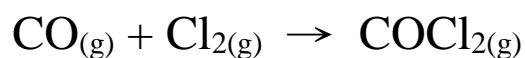
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一、The following reaction will form phosgene from carbon monoxide and chlorine:



Consider the following thermodynamic data:

Compound	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol · K)
$\text{CO}_{(g)}$	-110	-137	198
$\text{Cl}_{2(g)}$	0	0	223
$\text{COCl}_{2(g)}$	-223	-210	290

What is the entropy change for the formation of 1 mole of phosgene?

What can we learn from the Gibbs free energy of phosgene?

二、Cytochromes are a biologically important group of iron-containing molecules. They are important in redox processes. Part of the electron transfer process in the human body involves a transfer of an electron from cytochrome to cytochrome to cytochrome. The following are the standard reduction potentials for several cytochromes:

	$E^\circ$
$\text{Cytochrome b-Fe}^{3+} + e^- \rightleftharpoons \text{Cytochrome b-Fe}^{2+}$	+0.08V
$\text{Cytochrome c-Fe}^{3+} + e^- \rightleftharpoons \text{Cytochrome c-Fe}^{2+}$	+0.22V
$\text{Cytochrome a-Fe}^{3+} + e^- \rightleftharpoons \text{Cytochrome a-Fe}^{2+}$	+0.29V
$\text{Cytochrome a}_3\text{-Fe}^{3+} + e^- \rightleftharpoons \text{Cytochrome a}_3\text{-Fe}^{2+}$	+0.38V

Assuming that every electron transfer occurs spontaneously, could you determine the order of electron transfer for the cytochromes listed in the table?



三、Two harmonic waves are traveling in the same medium and are described by the following equations:

$$y_1 = 12\sin(3\pi x - 0.5\pi t)$$

$$y_2 = 12\sin(3\pi x - 0.5\pi t - 4)$$

where  $x$  and  $y$  are in meters and  $t$  is in seconds. What is the displacement of the resultant wave at  $x = 1.0$  m and  $t = 1.0$  s?

四、A man strikes a long steel rod at one end. Another man, at the other end with his ear close to the rod, hears the sound of the blow twice (once through air and once through the rod), with a 0.1 seconds interval between them. How can you determine the length of the rod? [For the steel, the bulk modulus =  $2.1 \times 10^{11}$  Pa, and the density =  $7.0 \times 10^3$  kg/m<sup>3</sup>. Speed of sound in air = 340 m/s.]

五、The unknown substance is being tested using four different test solutions (A, B, C, and D), each with a concentration of 1 M. The test solutions are identified as follows: A = NaCl, B = NaNO<sub>3</sub>, C = NaI, and D = Na<sub>2</sub>S. Upon mixing each of these test solutions with the unknown substance, the following observations were made: A resulted in a white precipitate, B showed no reaction, C resulted in a yellow precipitate, and D resulted in a black precipitate. Based on these observations, the unknown substance could potentially be identified.

六、請說明人類 5 種免疫球蛋白在結構上具有哪些共通特性？並說明其在分類上的主要差異？

七、根據含水 DNA 纖維之 X 射線繞射圖譜(X-ray diffraction photograph)，請說明 1953 年由 James Watson 和 Francis Crick 所推導之 DNA 結構模型之特徵為何？

八、假設不同氣體在相同溫度下有相同的動能，請分別計算以下兩種氣體組合之運動速率比值各為何？

(一) 氦氣與氮氣分子之運動速率比值

(二) 氧氣與硫化氫分子之運動速率比值

九、假設有一種溫度計，測定水之冰點為 $-50^{\circ}$ ，沸點為 $200^{\circ}$ ，若以此溫度計測得某一溶液顯示之溫度為 $80^{\circ}$ ，請問分別相當於攝氏、華氏及絕對溫度多少度？(請詳列其計算流程)

十、請說明真核生物(eukaryotes)其細胞中之胞器於演化過程中可能是如何形成的？