Hong Kong STEM Olympiad 2016 Briefing Session

Assessment Framework And Sample Questions

Assessment Framework

Science (S1-5)	Technology (T1-6)	Engineering (E1-14)	Mathematics (M1-7)
1. Understanding scientific knowledge/concepts 2. Applying scientific knowledge/concepts 3. Understanding scientific process (e.g. observation, designing experiments, testing variables, analyzing data) 4. Applying scientific processes 5. Searching for relevant scientific information	1. Understanding and using information technology 2. Identifying specific needs 3. Researching a specific problem 4. Referencing on previous experiences and observations 5. Evaluating the relevance and effectiveness of existing technologies 6. Adapting existing technologies to address the problem	1. Defining the problem 2. Identifying and understanding constraints (e.g., costs, users' habits, cultural norms, safety, availability of knowledge/materials, environmental impacts) 3. Determining criteria (e.g., efficacy, cost, sustainability) 4. Employing scientific knowledge/mathematical principles relevant to the problem setting 5. Generating multiple solutions/designs 6. Representing and communicating ideas by the use of sketches and drawings 7. Building models/prototypes/computer simulations for testing 8. Testing solutions against different criteria 9. Repeating tests under different conditions 10. Identifying effective aspects of various designs 11. Identifying reasons for failure 12. Improving designs by combining features tested to be effective 13. Prioritizing criteria and considering tradeoffs 14. Re-testing to optimize the final design/solution	1. Reasoning abstractly and quantitatively 2. Modeling with mathematics 3. Using mathematics and computational reasoning 4. Attending to precision 5. Using appropriate instruments for measuring 6. Taking accurate and precise measurements 7. Analyzing and representing data mathematically

Assessment Framework

Creativity and innovation (CI:1-3):

1. **Creative application of knowledge (S, T, E, M) for solving problems**
2. **Generating creative and innovative designs for solving problems**
3. **Creative application of skills to overcome difficulties in the engineering process**

Critical reasoning (CR1):

1. **Thinking critically in defining problems, applying knowledge, evaluating designs against criteria, prioritizing criteria, considering tradeoffs, arguing and justifying for the final designs/solutions**

Communication (C1):

1. **Communicating ideas, designs, test results, arguments and conclusions in a systematic and articulate manner**

Part I (a): Individual Knowledge Challenge (Physics, Chemistry, Biology, or ICT)

- Duration: **40 mins**
- Type of questions: **MC questions**
- **40+** questions in total
- Students are not expected to complete all questions and they should attempt those which they are most confident in giving the correct answers.
- **Scoring method:**
  - **2 or more marks for correct answer**
  - **0 mark for no answer**
  - **-1 mark for wrong answer (or more than one answer)**
  - **Some difficult/complex questions (with specific indication) will be scored with double or triple weighting**
- Questions will be mostly related to **HK DSE syllabus (including electives) but some may go beyond to certain popular STEM domains**

Part I (b): Team Knowledge Challenge

(Mathematics problems and Mathematics problems related to all the four areas)

- Duration: **40 mins**
- Type of questions: **MC questions**
- **20+ MCs for Mathematics problems**
- **20+ questions for Mathematics problems related to each of the four subjects (Phy/ Chem/ Bio/ICT)**
- Students are not expected to complete all questions and they should attempt those which they are most confident in giving the correct answers
- **Scoring method:**
  - **2 or more marks for correct answer**
  - **0 mark for no answer**
  - **-1 mark for wrong answer (or more than one answer)**
  - **Some difficult/complex questions (with specific indication) will be scored with double or triple weighting**
- Questions will be mostly related to **HK DSE syllabus (including electives) but some may go beyond to certain popular STEM domains**

Mode of Competition

- **Part II: Innovations in Practice**
  - Duration: **2 hours**
  - Type of questions: **Hands-on problem solving and design**
  - Assessment criteria and methods: **announcement on the site**

Sample Questions – Part I(a)

- **Physics**

Q1) Which of the following statements must be correct about cooking and food?

(1) For the same piece of meat, the internal energy of a hot piece of meat is larger than that of a frozen one.

(2) By using electric stove in cooking, the stove and the internal bottom of the frying pan must have the same temperature.

(3) When crushed ice is added into a cup of hot soup, all ice must melt immediately.

A. (1) only
B. (2) only
C. (2) and (3) only
D. (1) and (3) only

Q1) 以下關於煮食及食物的句子，哪一句必定正確?

(1) 就相同肉塊以言，熱肉塊的內能大於冷藏肉塊。

(2) 以無火電爐煮食時，電爐及平底鑊的內部底部溫度必定一樣。

(3) 當碎冰加入熱湯中，所有冰都必定立即融化。

A. 只有(1)
B. 只有(2)
C. 只有(2)和(3)
D. 只有(1) 和(3)

Answer: A

Sample Questions – Part I(a)

- **Physics**

Q4) Laser pointer is a common device nowadays. Which of the followings about the laser beam from the laser pointer is false?

A. When the laser beam from a laser pointer strikes a rough surface, the law of reflection does not apply.
B. The stronger the laser beam from a laser pointer, the wider the spectrum of wavelengths given out by the laser pointer.
C. When laser beams of different colour enter a vacuum chamber in a glass jar from air, the different laser beams have the same speed in the vacuum chamber.
D. A red beam travels lower than a green laser beam in glass.

Q4) 激光指示器是一種常見的工具，以下哪一句關於激光指示器的激光光束是錯的?

A. 當激光指示器的激光光束照射於粗糙平面上，反射定律並不適用。
B. 激光指示器的光束越強，所發出的光譜越寬。
C. 當不同顏色的激光光束從空氣入射至在玻璃瓶中的真空空間，不同顏色的激光光束在真空中的速度一樣。
D. 在玻璃中紅色激光比藍色激光行得更快。

Answer: B

Sample Questions – Part I(a)

- **Physics**

Q5) Radioactive tracers are sometimes used to obtain medical images. A patient has been injected with a radioactive source Tc-99m with an initial activity of 20 units. The physical half-life of Tc-99m is 6 hours. What is the activity of the source after 15 hours?

A. Less than 3 units
B. About 3-4 units
C. About 5-6 units
D. Cannot be determined

Q5) 放射性示踪劑常用於醫學攝影。假設將初始活度為 20 個單位的 Tc-99m 放射源注入一病人體內，而該 Tc-99m 的物理半衰期為 6 小時。那麼 15 小時後該放射源的活度為多少?

A. 少於 3 個單位
B. 大約 3-4 個單位
C. 大約 5-6 個單位
D. 無法判斷

Answer: B

Sample Questions – Part I(b)

- **Physics**

Q1) An object of mass m accelerates uniformly from rest to a speed v_f in time t_f. Which of the followings is the work done on the object as a function of time t?

Q1) 一質量為 m 的物件在時間t_f內由靜止均勻加速至速度v_f。以下哪一個是作用於該物件的功對時間 t 的關係?

A. $W = \frac{1}{2} m \frac{v_f^2}{t_f^2} t^2$

B. $W = m \frac{v_f^2}{t_f^2} t^2$

C. $W = \frac{1}{2} m \frac{v_f^2}{t_f} t$

D. $W = m \frac{v_f^2}{t_f} t$

Solution: $a = \frac{v_f}{t_f}$

$$W = Fs = mas = ma\left(\frac{1}{2}at^2\right) = \frac{1}{2}ma^2t^2 = \frac{1}{2}m\left(\frac{v_f}{t_f}\right)^2 t^2$$

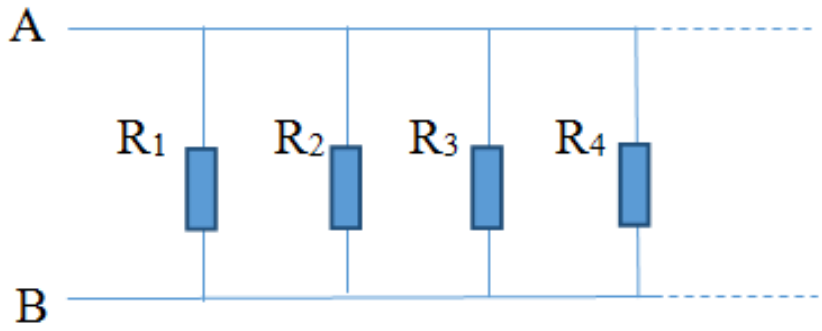
Answer: A

Sample Questions – Part I(b)

- **Physics**

Q3) Consider the following circuit with infinitely many parallel resistors. The resistances of the resistors are in geometric sequence with a fixed ratio 2. Assume that $R_1 = 16\ \Omega$. We have $R_2 = 32\Omega$, $R_3 = 64\ \Omega$, etc. What is the equivalent resistance of AB?

Q3) 考慮以下一組由無數多的電阻組成的電路。所有電阻的數值可以組成一個比例為 2 的幾何序列。假設 $R_1 = 16\ \Omega$，我們可得出 $R_2 = 32\ \Omega$、$R_3 = 64\ \Omega$、如此類推。那麼 AB 的總電阻為多少?



Solution: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

$$\frac{1}{R} = \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \cdots = \frac{\frac{1}{16}}{1 - 0.5} = \frac{1}{8}$$

$$R = 8\ \Omega$$

A. $2\ \Omega$
B. $4\ \Omega$
C. $8\ \Omega$
D. $16\ \Omega$

Answer: C

Sample Questions – Part I(b)

- **Physics**

*Q4) In a galaxy, stars are orbiting about the centre of galaxy. Suppose the mass of a galaxy follows $M(r) = Cr$, where r is the distance from the centre of galaxy and C is a constant. (a) Which of the followings is a possible implication? (b) Which of the followings is a possible relation between the mass density of the galaxy ρ and$r$. (1 mark for (a) and 2 marks for (b))

Answers for (a)

A. The orbital speeds of stars in the galaxy are constant for different r.
B. The orbital speeds of stars in the galaxy increase with r.
C. The orbital speeds of stars in the galaxy decrease with r.
D. No implication can be obtained.

Answers for (b)

A. $\rho \propto r$

B. $\rho \propto \frac{1}{r}$

C. $\rho \propto \frac{1}{r^2}$

D. $\rho \propto r^2$

Sample Questions – Part I(b)

- **Physics**

*Q4) 在一星系中，所有星體都圍繞著星系的中心公轉。假設一星系的質量為 $M(r) = Cr$，當中 r 為與星系中心的距離而 C 是一常數。(a) 以下哪一項是可能的結論? (b) 以下哪一項是該星系密度ρ與r的關係? ((a)佔一分而(b)佔兩分)

(a)部分的答案

A. 星系中星體的公轉速度在不同的 r 是不變的。
B. r的數值星愈大，星系中星體的公轉速度也愈大。
C. r的數值星愈小，星系中星體的公轉速度也愈小。
D. 沒有任何結論可以得到。

(b)部分的答案

A. $\rho \propto r$
B. $\rho \propto \frac{1}{r}$
C. $\rho \propto \frac{1}{r^2}$
D. $\rho \propto r^2$

Solution:

(a) $v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GCr}{r}} = \sqrt{GC} = constant$

Answer: A

Sample Questions – Part I(b)

- **Physics**

*Q4) 在一星系中，所有星體都圍繞著星系的中心公轉。假設一星系的質量為 $M(r) = Cr$，當中 r 為與星系中心的距離而 C 是一常數。(a) 以下哪一項是可能的結論? (b) 以下哪一項是該星系密度ρ與r的關係? ((a)佔一分而(b)佔兩分)

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C. r的數值星愈小，星系中星體的公轉速度也愈小。
D. 沒有任何結論可以得到。

(b)部分的答案

A. $\rho \propto r$
B. $\rho \propto \frac{1}{r}$
C. $\rho \propto \frac{1}{r^2}$
D. $\rho \propto r^2$

Solution:

(a) $v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GCr}{r}} = \sqrt{GC} = constant$

Answer: A

Sample Questions – Part I(b)

- **Physics**

*Q4) 在一星系中，所有星體都圍繞著星系的中心公轉。假設一星系的質量為 $M(r) = Cr$，當中 r 為與星系中心的距離而 C 是一常數。(a) 以下哪一項是可能的結論? (b) 以下哪一項是該星系密度ρ與r的關係? ((a)佔一分而(b)佔兩分)

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A. 星系中星體的公轉速度在不同的 r 是不變的。
B. r的數值星愈大，星系中星體的公轉速度也愈大。
C. r的數值星愈小，星系中星體的公轉速度也愈小。
D. 沒有任何結論可以得到。

(b)部分的答案

A. $\rho \propto r$
B. $\rho \propto \frac{1}{r}$
C. $\rho \propto \frac{1}{r^2}$
D. $\rho \propto r^2$

Solution:

(b) $M = \frac{4}{3}\pi r^3 \bar{\rho}$, where $\bar{\rho}$ is the enclosed average density.

$$Cr = \frac{4}{3}\pi r^3 \bar{\rho} \rightarrow \bar{\rho} = \frac{3C}{4\pi r^2}$$

Since the enclosed average density $\propto 1/r^2$
The density also goes as $1/r^2$

Answer: C

Sample Questions – Part I(a)

- **Chemistry**

(1) A man has been collecting three coins (gold, silver and copper) for a long time. One day he observed a black coating on some coins and green coating on some other coins. Which of the following statement(s) is/are the correct?
某人收集三枚硬幣（金，銀，銅），放置了很長一段時間。有一天，他觀察到一些硬幣表面有黑色物質覆蓋，另外一些有綠色物質覆蓋。以下哪項陳述是正確的？

(i) The coating occurred due to a chemical process called corrosion.
硬幣表面生成的物質的過程叫化學腐蝕

(ii) Black coating on silver is due to deposit of Silver Sulphide (Ag_2S).
銀表面的黑色物質是因為表面生成了硫化銀(Ag_2S)

(iii) Green coating on copper is due to formation of Copper Carbonate ($CuCO_3$).

(iv) 銅表面的黑色物質是因為表面生成了碳酸銅($CuCO_3$))

(v) Silver usually is corrosion resistant and does not oxidize. However presence of sulphur gases in atmosphere can react and cause sulphur-corrosion.
銀一般是抗腐蝕而不會被氧化。但是，當將銀置於含硫氣氛之中時，它會被反應，發生硫腐蝕

(a) (i) and (ii) (i) 和(ii)
(b) (i) , (ii) and (iii) (i) , (ii) 和 (iii)
(c) (ii), (iii) and (iv) (ii), (iii)和 (iv)
(d) (i), (iii) and (iv) (i), (iii) 和 (iv)
(e) All 以上所有陳述

Answer: e

Sample Questions – Part I(a)

- **Chemistry**

(2) The unwanted pollutants from the exhausts of vehicles include unburnt hydrocarbons (HCs), carbon monoxide and oxides of nitrogen, mainly NO and NO_2. The first two pollutants arise if there is insufficient oxygen present to oxidize them fully. The oxides of nitrogen are formed in larger quantities if too much oxygen is present. Which of the following statement(s) is/are the correct?
從車輛的廢氣的無用污染物包括未完全燃燒的碳氫化合物（HCs），一氧化碳和氮氧化物，主要是NO和NO_2。如果氧氣不足，則因不能被完全氧化而主要生成前兩種污染物。但如果氧氣存在過多，則又會形成大量的氮氧化物。以下哪項陳述是正確的？

(i) Any unburnt hydrocarbons and carbon monoxide can be removed by being oxidised, either by oxygen or water.
所以未充分燃燒的碳氫化合物和一氧化碳都能通過氧氣或者水使其氧化而被去除

(ii) Any unburnt hydrocarbons and carbon monoxide can be removed by being oxidised, either by oxygen or water with platinum and/or palladium metal as catalyst(s).
所以未充分燃燒的碳氫化合物和一氧化碳，在以金屬箔或者金屬鈀為催化劑的條件下，都能通過氧氣或者水使其氧化而被去除

(iii) The nitrogen oxides must be removed by being reduced to nitrogen gas with carbon monoxide and hydrogen gas present.
氮氧化物必須在一氧化碳和氫氣存在的條件下才能被還原成氮氣而去除

(iv) The nitrogen oxides must be removed by being reduced to nitrogen gas with carbon monoxide and hydrogen gas present. These reduction reactions are catalysed by rhodium metal.
氮氧化物必須在一氧化碳和氫氣存在的條件下才能被還原成氮氣而去除，發生這些還原反應的催化劑為金屬銠。

(a) (i) and (iii) (i) 和 (iii)
(b) (i) and (iv) (i)和 (iv)
(c) (ii) and (iii) (ii) 和(iii)
(d) (ii) and (iv) (ii)和 (iv)
(e) None of the above 所以都不是

Answer: d

Sample Questions – Part I(a)

- **Chemistry**

(3) A coffee company has recently launched a self-heating can of coffee. To heat up the coffee, a button is pressed which mixes the heating ingredients – a very dilute solution of sodium / potassium hydroxide and calcium oxide. The can then warms up 210 ml (210 cm^3) of coffee by approximately 40 °C.
咖啡公司最近推出的自加熱咖啡罐。按下一個按鈕，氫氧化鉀/鈉的稀溶液將和氧化鈣稀溶液混合而達到加熱的效果，能將一罐約210毫升(210 立方釐米)的咖啡升溫到40℃。

If we want to control the heating rate of the can, we can alter the pH of the solution. How would you expect the rate of reaction to vary in acidic, basic and neutral conditions in the order in which they affect the rate of reaction, fastest first?
如果我們想控制罐的加熱速度，我們可以改變溶液的pH值。酸性，中性和鹼性將會如何影響反應速率，按照影響由大到小的順序排列是？

(a) Acidic, basic, neutral 酸性，鹼性，中性
(b) Acidic, neutral, basic 酸性，中性，鹼性
(c) Neutral, acidic, basic 中性，酸性，鹼性
(d) Basic, neutral, acidic 鹼性，中性，酸性
(e) Basic, acidic, neutral 鹼性，酸性，中性

Answer: b

Sample Questions – Part I(b)

- **Chemistry**

(4) Referring to (3), assuming that the heat capacity for the coffee is the same as that of water, 4.18 JK^{-1} g^{-1}, calculate (i) the energy needed to warm 210 ml of coffee by 40 °C. Hence calculate (ii) the minimum mass of calcium oxide needed in the can to function as specified. (Given: $CaO + H2O \rightarrow Ca(OH)_2$ provides 82kJ)

(a) (i) 70.2kJ, (ii) 24.0g
(b) (i) 70.21kJ, (ii) 48.0g
(c) (i) 35.1kJ, (ii) 24.0g
(d) (i) 35.1kJ, (ii) 48.0g
(e) None of the above

Solution:
To warm 1g by 1°C requires 4.18 J, 210g by 40°C requires 4.18 x 210 x 40 J = **35.1 kJ**
1 mol CaO provides 82 kJ. We need 35.1 kJ = 35.1 / 82 mol = 0.428 mol. Taking RMM for CaO as 56, minimum mass required = 56 x 0.428 = **24.0 g**

Answer: c

Sample Questions – Part I(b)

- **Chemistry**

(5) Outdoor flames, such as outdoor heaters and the Olympic flame, contribute to global warming. This is not only due to the heat released, but also due to the carbon dioxide produced from the combustion of hydrocarbons. Most outdoor heaters are powered by small cylinders of propane gas. A typical outdoor heater designed to produce 15 kW of energy runs from a cylinder containing 13 kg of propane. The standard enthalpy change of combustion of propane is -2220 kJ mol^{-1}. Assume 1 mole of a gas occupies 24 dm^3 under the conditions of this question.

Calculate (i) the mass of carbon dioxide produced when all of the propane in a cylinder is burnt completely and (ii) the total amount of heat energy released by combustion of all the propane in a cylinder.

(a) (i) 38.9 kg (ii) 655 kJ
(b) (i) 13.0 kg (ii)655 kJ
(c) (i) 38.9 kg (ii) 650000 kJ
(d) (i) 13.0 kg (ii)655000 kJ
(e) None of the above

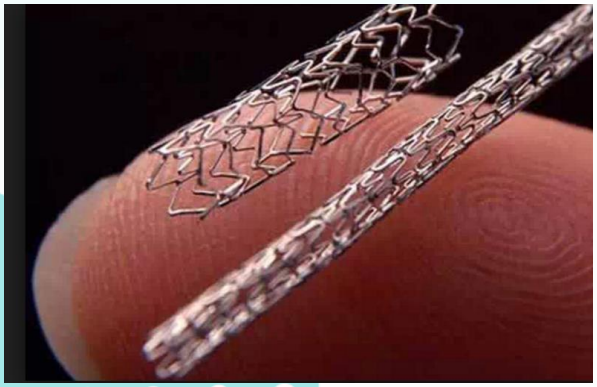
Solution: (i) Moles = 13000/44.1 = 295; Mass = 3 x 295 x 44.0 = 38900 g = 38.9 kg
(ii) Heat energy = 2220 x 295 = 655000 kJ = 655 MJ

Answer: c

Sample Questions – Part I(a)

- **Biology**

The following diagram shows a kind of device which can treat coronary heart disease.
下圖顯示一種能治療冠心病的儀器。



(Image source: www.cmoney.tw)

Which of the following description about such device is correct?
以下哪項能正確描述這個儀器？

(i) It restores blood flow at the treated area.
它回復治療位置的血流量。

(ii) It can be applied to all types of blood vessels.
它適用於所有類型的血管。

(iii) It compresses the surrounding plaques.
它會壓縮週邊的血斑塊。

A. (i) only
只有 (i)

B. (ii) only
只有 (ii)

C. (i) and (iii) only
只有 (i) 及 (iii)

D. (i), (ii) and (iii)
(i), (ii) 及 (iii)

Answer: C

Sample Questions – Part I(a)

- **Biology**

Recombinant DNA Technology is central to genetic engineering. What is/are the possible challenge(s) when developing or applying such technology?
DNA重組技術對遺傳工程極為重要。在發展或應用該技術時，以下哪項是可能遇到的挑戰？

(i) To control the gene expression of recombinant DNA.
控制重組DNA的基因表達

(i) To find living host bacteria because they will be dead when vector is isolated.
找出可存活的寄主細菌，因為當載體移離時，寄主細菌將會死亡

(i) To find enzymes which can breakdown the linkage between complementary base pairs of DNA.
找出可以分離DNA中互補鹼基對的酶

A. (i) only
只有 (i)

B. (i) and (iii) only
只有 (i) 及 (iii)

C. (ii) and (iii) only
只有 (ii) 及 (iii)

D. (i), (ii) and (iii)
(i), (ii) 及 (iii)

Answer: A

Sample Questions – Part I(a)

- **Biology**

Every year, 3500 button batteries being swallowed are reported in the United States. A group of the US researchers attempt to produce a tiny robot for removing a swallowed battery. Which of the following would be the criteria that the researchers ought to meet?
在美國，每年有3500粒電池被誤吞。一群美國的研究員嘗試製造微型機械人以移除誤吞的電池。以下哪項是研究員須達到的標準？

(i) The robot fits inside a capsule.
機械人可置於膠囊內。

(ii) The robot efficiently propels itself in liquid medium.
機械人能有效地在液體中推進。

(iii) The material of the robot is very hard.
機械人的物料要非常堅硬。

A. (i) only
只有 (i)

B. (i) and (ii) only
只有 (i) 及 (ii)

C. (ii) and (iii) only
只有 (ii) 及 (iii)

D. (i), (ii) and (iii)
(i), (ii) 及 (iii)

Answer: B

Sample Questions – Part I(b)

- **Biology**

Phylogenetics is the biological discipline to elucidate the evolutionary relationship among different organisms. In recent years with the advances in DNA-biotechnology, scientists start to reveal the evolutionary relationship between organisms using the similarity of the genetic codes for given genes.
In the case of mitochondrial genes, one species will only possess one set of genes due to the haploid nature. Assuming scientists have revealing the nucleotide sequences of four bird species for a given mitochondrial gene as below:

親緣關係學是生物學的一個範疇，以闡明不同生物之間的演化關係。近年，因著有關DNA生物科技的進步，科學家開始利用特定基因的遺傳密碼相似度，展示生物間的演化關係。
基於線粒體單倍體的特性，一個物種線粒體內的基因只有一套。假設科學家已找出四個鳥類物種中的某一線粒體基因的核苷酸序列，如下圖：

Bird Species鳥類物種 A: ATCGGGTTTTAAAACCCCTTTAATATATCCATTTAAACCGGCCGCTGTCA

Bird Species鳥類物種 B: ATCGGGTTTTAAAACCCCTTTAATATATCCATTTAAACCGGCCGATGTCA

Bird Species 鳥類物種C: ATCGCGTTTTAAACCCCCTTTAATATATCCATATAAACCGGCCGGTGTCA

Bird Species 鳥類物種D: ATCGCGTTTTAAACCCCCTTTAATATATCCATATAAACCGGCCGGTGGCA

Sample Questions – Part I(b)

- **Biology**

What is the percentage of similarity in terms of the genetic code between Species A and C?
物種甲與物種丙的遺傳密碼相似百分比是多少？

A.8%
B. 4%
C. 92%
D. 96%

Solution:
There are totally 50 base pair revealed. The number of the base-pair difference between species A and C are 4.

The percentage difference is 4/50 X 100% = 8%
The percentage of similarity would be (1-dissimilarity) = 92%

Answer: C

Sample Questions – Part I(b)

- **Biology**

How many pairs of species are there if we carry out a pairwise comparison?

若我們進行一對一的比較，將會有多少對物種配對會產生？

A. 3
B. 6
C. 8
D. 12

Solution:
There are 4 species, so the comparison between species would be 3! = 3 x 2 x1 = 6
Ie. A vs B, A vs C, A vs D, B vs C, B vs D, C vs D

Answer: B