香港國際科學競賽初賽 2019 - 2020（香港賽區）

HONG KONG INTERNATIONAL SCIENCE OLYMPIAD
HEAT ROUND 2019 - 2020 (HONG KONG REGION)

高中組 Senior Secondary Group

時限：60 分鐘

Time allowed: 60 minutes

模擬試題
Mock Paper

考生須知：

Instructions to Contestants:

1. 本卷包括 試題 乙份，試題紙不可取走。

   Each contestant should have ONE Question-Answer Book which CANNOT be taken away.

2. 本卷共 4 個範疇，每範疇有 5 題，共 20 題，答對得 2 分，空題得 0 分，**答錯倒扣 1 分。**

   There are 4 exam areas and 5 questions in each exam area. There are a total of 20 questions in this Question-Answer Book. Two points for correct answers. No points for incorrect answers. **ONE penalty point will be deducted for incorrect answers.**

3. 請將答案寫在 答題紙 上。

   All answers should be written on ANSWER SHEET.

4. 比賽期間，小學組不得使用計算工具，**中學組可以使用計算工具。**

   During the contest, NO calculators can be used for PRIMARY GROUP **but calculators can be used for SECONDARY GROUP**.

5. 本卷中所有圖形不一定依比例繪成。

   All figures in the paper are not necessarily drawn to scale.

6. 比賽完畢時，本試題會被收回。

   This Question-Answer Book will be collected at the end of the contest.

本試題不可取走。

請將答案寫在 答題紙 上。

All answers should be written on the ANSWER SHEET.

THIS Question-Answer Book CANNOT BE TAKEN AWAY.

未得監考官同意，切勿翻閱試題，否則參賽者將有可能被取消資格。

DO NOT turn over this Question-Answer Book without approval of the examiner.

Otherwise, contestant may be DISQUALIFIED.

選擇題（第 1 至 20 題）（答對得 2 分，空題得 0 分，**答錯倒扣 1 分**）

Multiple Choice Questions (1st ~20th) (Two points for correct answers. No points for incorrect answers. **ONE penalty point will be deducted for incorrect answers.**)

Physics
物理

1. Bats use ultrasonic waves to catch prey. A bat is following a moth along the +x direction. The speeds of the bat and moth are 9 m/s and 8 m/s, respectively. The bat emits an ultrasonic wave with a frequency of 82.5 kHz and detects a reflected wave from the moth. The velocity of sound is 340 m/s.

   Which of the following is the closest frequency for the detected wave?
   A. 82.7 kHz   B. 82.8 kHz   C. 82.9 kHz   D. 83.0 kHz   E. 83.1 kHz

2. A ball of mass 1.0 kg is projected with a horizontal velocity of 10 m/s from the edge of a building at a height of 20 m. While falling, the ball splits into two identical pieces, X and Y. Then, X and Y hit the ground at a point 10 m and R horizontally from the building, respectively. The gravitational acceleration is $10\,ms^{-2}$.
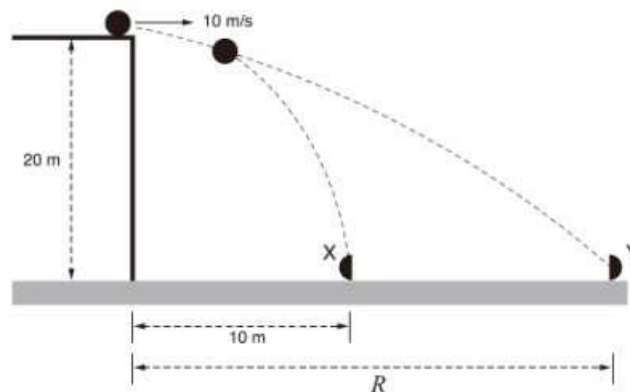

   What is the distance R?
   A. 20 m   B. 30 m   C. 40 m   D. 50 m   E. 60 m

3. A ball X with mass m travels on a frictionless track, as shown in the figure below. After barely rotating on a circular track of radius R, X collides with another ball Y, which has mass 2m and is initially at rest. After the collision, X and Y stick together and move. What is $\dfrac{K_x}{K_{xy}}$? (K_x and K_{xy} are the kinetic energies of X just before the collision and of XY after the collision, respectively.)
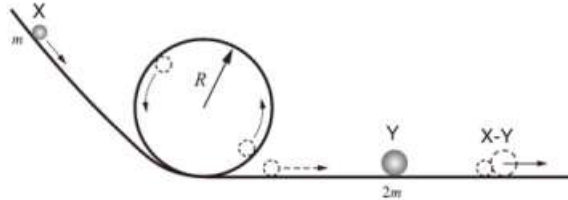
A. 0   B. 1   C. 2   D. 3   E. 4

4. A block of mass m is released from one rim of a hemispherical bowl of radius R. In the presence of friction, the block finally stops at the bottom of the hemisphere after oscillating left and right. What are the works done by gravitational and normal forces?

	A	B	C	D	E
Work done by gravitational force	0	mgR	0	mgR	Cannot be calculated
Work done by normal force	0	0	mgR	mgR	Cannot be calculated

5. A tank is divided into two compartments X and Y with a thermally-insulating wall that can move without friction. X and Y contain an ideal gas at the same pressure P, volume V, and temperature T as shown in the figure below. After the temperature of X increases to $3T$, the system reaches an equilibrium state. The temperature of Y remains constant at T throughout the time. What is the gas pressure of Y at the equilibrium?
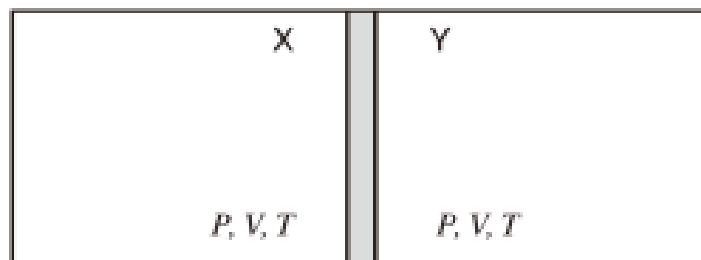
A. P B. $1.5P$ C. $2P$ D. $3P$ E. $3.5P$

Biology
生物

6. The pathways and reactions involved in the nitrogen cycle are complicated. The following describes some parts of the nitrogen cycle. Which of the following chooses all and only the correct statements from the box below?

1. Nitrogen is fixed to organic nitrogen by plants and humans.
2. X and Y are degradation processes by bacteria.
3. Z is a denitrification process by bacteria.
4. The pathways of NH_4^+, NO_3^- and NO_2^- to organic nitrogen are involved in the uptake by plants.

A. 1 & 2   B. 1 & 3   C. 2 & 3   D. 2 & 4   E. 1

7. The figure below shows the distribution of optic cells X and Y in the retina.
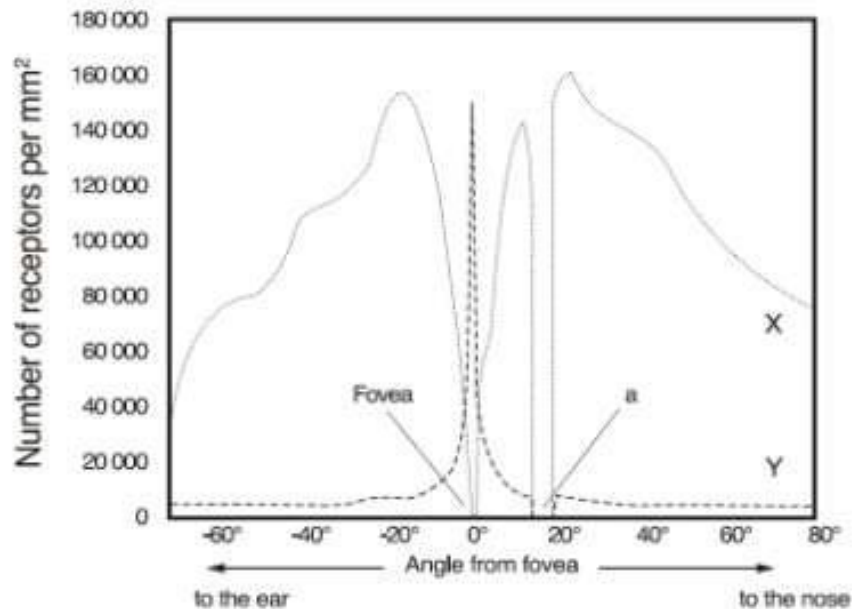
Which of the following chooses all and only the correct statements from the box below?
1. X is usually located in the center of the retina.
2. X is less sensitive to light than Y.
3. "a" is the position of the blind spot.
4. The ratio of the number $\dfrac{X}{Y}$ is much higher in nocturnal animals than in diurnal ones.

A. 1 & 2   B. 1 & 3   C. 2 & 3   D. 3 & 4   E. 2

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8. DNA is composed of double strands, and one of these double strands can be used as a template to produce mRNA by the process of transcription. Consider DNA double strands where the base ratio of A+T/G+C in the double strands is 1/4 and each strand has 1000 bases. The table below shows the base compositions of strands I and II, and the mRNA transcribed by one of the double strands.

		Base composition (number)					
		G	A	T	C	U	Sum
DNA Strands	I			150			1000
	II				500		1000
mRNA					(X)	150	1000

Which of the following statements is NOT correct?
A. The number for X is 350.
B. The number for A+G in strand I is 550.
C. Strand II was used as the template for the mRNA.
D. The total number of hydrogen bonds between A and T in the double strands is 400.
E. All of the above

9. The figure below shows the process of egg production and early development of a fertilized egg in the human reproduction system.
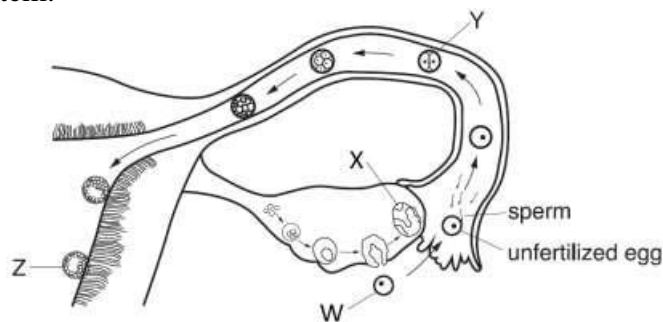
Which of the following statements is NOT correct?
A. Three polar bodies are attached to W.
B. X produces progesterone.
C. The chromosome number for each cell in Y is 46.
D. Z is at the stage of blastocyst
E. All of the above

10. Twenty flies are each placed four glass tubes (I –IV) and the tubes sealed. While tubes I and II are partly covered with foil to protect from exposure to light, tubes III and IV are not covered. The experiments 1 and 2 show the distribution of the flies in each tube when the tubes are exposed to red light and blue light, respectively.

Which of the following statements about the experiments is NOT correct?
A. The experiments are testing the response of the flies to red and blue light and gravity.
B. Tubes II 和 IV are serving as the controls for the light variable.
C. Experiment 1 shows that flies respond to gravity, yet not to red light.
D. From experiments 1 and 2, it can be concluded that flies react to blue light, yet not red light.
E. All of the above

Chemistry
化學

11. Below is incomplete information for neutral atoms I and II.

Atom	I	II
Number of protons		7
Number of neutrons	7	a
Number of electrons	7	b
Mass number		15

    Which of the following is correct?
    A. $a = 7$
    B. $b = 8$
    C. Atomic number of I is 14.
    D. I and II are isotopes of the same element.
    E. All of the above

12. Which of the following is the correct order of the decreasing ionic radius for Na^+, Mg^{2+}, O^{2-}, and F^-?
    A. $Na^+ > Mg^{2+} > F^- > O^{2-}$
    B. $Mg^{2+} > Na^+ > O^{2-} > F^-$
    C. $O^{2-} > F^- > Na^+ > Mg^{2+}$
    D. $F^- > O^{2-} > Mg^{2+} > Na^+$
    E. None of the above

13. Which of the following molecules has a non-zero dipole moment?
    A. CO_2
    B. CCl_4
    C. C_2H_2
    D. H_2Se
    E. None of the above

14. The reaction rate is the change in concentration of a reactant or product with time, the unit of which is M/s. When the reaction rate depends on the n-th power to the concentration of a reactant, [R]:

$$\text{Reaction Rate } = k[\text{R}]^n$$

where k is the rate constant, it is called an n-th order reaction. The following graph shows [R] as a function of time for the chemical reaction R $\rightarrow$ P. (P denotes the product). M = moles/litre
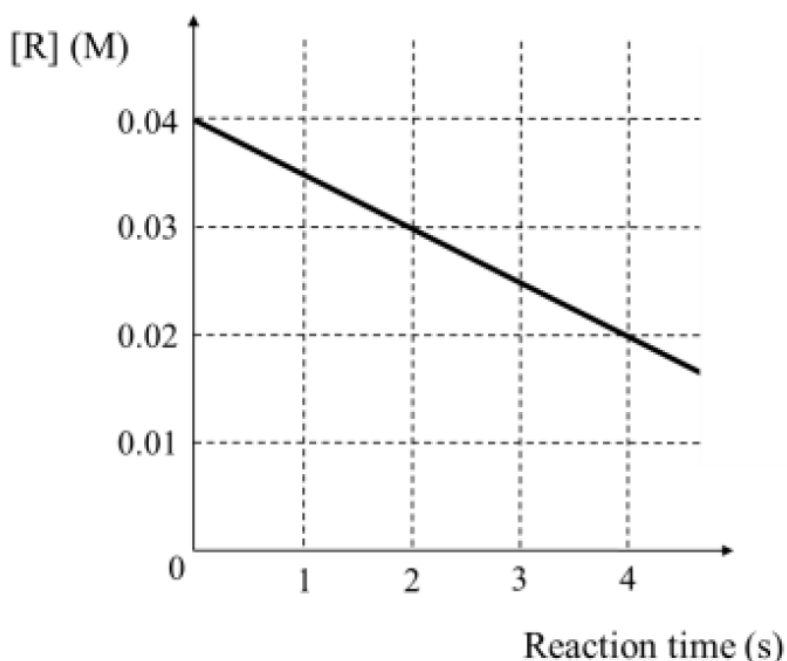
Which of the following is correct for both n and the unit of k for the reaction R $\rightarrow$ P?

A. 0, 1/s
B. 0, M/s
C. 1, 1/s
D. 1, M/s
E. None of the above

15. A gaseous hydrocarbon **X** has a density of 1.25 g/L at 0 °C and under 1 atm. What is the mass fraction of carbon in **X**? (The atomic masses of carbon and hydrogen are 12.0 and 1.00 g/mol, respectively, and 1.00 mole of gas occupies a volume of 22.4 L at 0 °C and under 1 atm.)

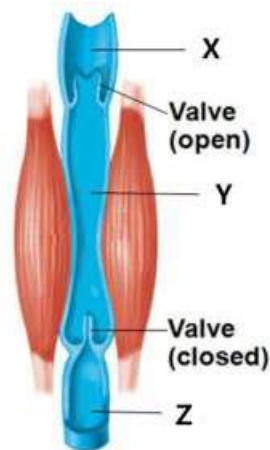A. 75%   B. 80%   C. 85.7%   D. 92.3%   E. 100%

Integrated Science
綜合科學

16. The figure below shows a vein and contracted muscles surrounding the vein in the leg of a normal person.
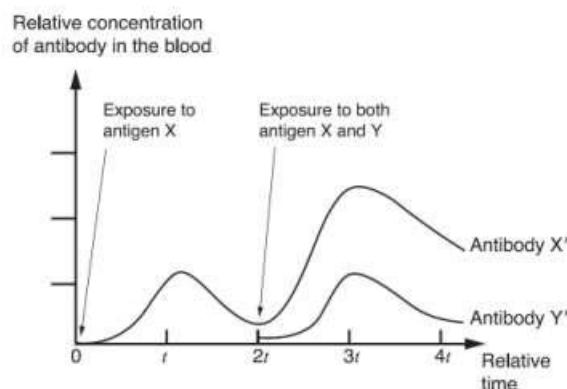

Which of the following chooses all and only the correct statements from the box below?
1. The blood pressure at Y is higher than at X in this situation.
2. The blood flows from X to Y when the muscles relax.
3. The blood flows from Y to Z when the muscles contract.

A. 1   B. 2   C. 1 & 3   D. 2 & 3   E. 1 & 2 & 3

17. The figure below shows the change of relative concentrations of antibody X' and Y' in the blood depending on the time course when animals are exposed to antigen X and Y. The animals have not been previously exposed to antigen X or Y.

Which of the following chooses all and only the correct statements from the box below?
1. Without antigen X, antibody Y´ would not be produced during $2t \sim 3t$.
2. The rapid increase of antibody X´ during $2t \sim 3t$ is due to memory cells against antigen X.
3. The increased production of antibody X´ during $2t \sim 3t$ is because antigen X and Y have acted together.

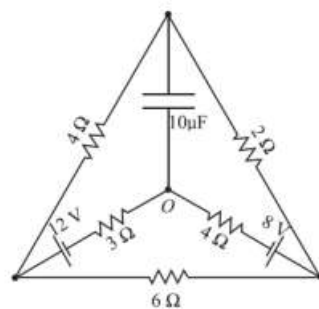A. 1   B. 2   C. 1 & 2   D. 2 & 3   E. 1 & 2 & 3

18. What is the electron configuration for the most stable ion of 13Al?
    A. $1s^2 2s^2 2p^6 3s^2$
    B. $1s^2 2s^2 2p^6$
    C. $1s^2 2s^2 2p^5 3s^1$
    D. $1s^2 2s^2 2p^6 3p^2$
    E.   None of the above

19. The figure below is a circuit containing two batteries, five resistors, and one capacitor.

    What is the current at point O after sufficient time has passes?
    A. 0.1 A
    B. 0.2 A
    C. 0.4 A
    D. 0.8 A
    E. 1.6 A

20. A person takes a picture of a waterweed in a fishbowl using a camera with a convex lens. The fishbowl is filled with water of which the refractive index is $\frac{4}{3}$. When the film, lens, and waterweed are positioned as shown in the figure below, a clear image of the waterweed is recorded on the film.
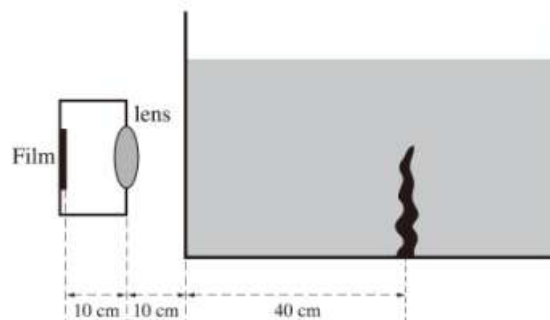
    What is the focal length of the convex lens?
    A. 8 cm
    B. $\frac{50}{6}$ cm
    C. $\frac{110}{13}$ cm
    D. 9 cm
    E. 10 cm

請將答案寫在 答題紙 上。

All answers should be written on the ANSWER SHEET.

~ 全卷完 ~
~ End of Paper ~