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# 2024 GENERAL SCIENCE COMPETITION

Sample Booklet  
with  
Sample Questions

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uOttawa

Faculté des sciences  
Faculty of Science

## ***General Instructions***

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### ***Registration:***

If you are interested in registering for the 2024 General Science Competition, please fill out the form in this link: :

<https://forms.gle/xosxCdK7uzKZ2t8C6>

Once submitted, we will confirm the registration by email at a later date. Deadline to register is April 19th, 2024.

### ***Before the competition:***

Students must join the Zoom call 20 minutes before the beginning of the competition to sign in with their proctor.

### ***During the competition:***

The Zoom meeting will be recorded during the competition. Students are NOT allowed to ask questions during the competition. Students will be muted for the duration of the call. This test is open-book and students will be allowed to access the internet and use any print materials. However, students must complete the competition individually and cannot seek outside assistance from other persons.

A 5 minute and a 1 minute warning will be given before the end of the competition. Students must submit their Google form by 8:00pm EST, a 1 minute grace period will be given.

### ***After the competition:***

The scores will be reviewed and the top 3 scoring students will be notified by email on Monday, May 27th, 2024.

The final score will be calculated as follows: Each correctly answered question is worth 1 point. Each incorrectly answered question will contribute a half mark deduction. No points will be awarded or deducted for unanswered questions. The rankings will be determined by the final score.

## ***Prize Information***

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### **Admission Scholarship:**

The University of Ottawa's Faculty of Science will be awarding admission scholarships for the winners of the 2024 General Science Competition. A total of \$7,000 in non-renewable first year admission scholarships will be awarded. \$3,500 of the \$7,000 will be awarded to English school contestants.

The total prize amount will be divided as follows: \$2,000 for first place, \$1,000 for second place, and \$500 for third place. The rankings will be determined by the final score. In the event of a tie, the time of the last form submission will be used as a tiebreaker. If there is a tie for first place, the first and second place scholarships will be decided based on awarding first place to the student who submitted their last form first between the tying students. The next highest ranked student will receive the third place scholarship. In the event of a second place tie or a third place tie, the scholarships will be divided accordingly.

### **Eligibility for Admission Scholarships:**

In order to be eligible to receive the non-renewable first year admission scholarship, the winners must be accepted and enroll in a program within the **Faculty of Science at the University of Ottawa**.

The winners must also notify uEducate by email of the acceptance of the admission scholarship **AND** accept the conditional offer of admission from the University of Ottawa by **June 3rd, 2024** (if applicable).

Upon confirmation of registration at the University of Ottawa, the admission scholarship will be credited to the account of the winners. Students may defer the acceptance of their scholarship if they are not graduating from secondary school at the end of 2024.

***\* The Faculty of Science will make the final decision on the awarding of the scholarship prizes as such the terms of eligibility are subject to change.***

The 2024 General Science Competition results are **independent** from the University of Ottawa admission process.

**GENERAL SCIENCE COMPETITION**  
**Sample 2024**

**ENGLISH**



**Duration: 60 minutes (1 hour)**

There are three sections:

**Section A:** Physics  
**Section B:** Chemistry  
**Section C:** Biology

Please follow the instructions:

**General Instructions:**

- Join the Zoom call 20 minutes before the beginning of the competition to sign in with their proctor (at 6:40 pm).
- Online and printed resources are permitted. This competition is to be completed individually and no outside assistance from other people is permitted.
- Only complete 2 of the 3 sections provided (A+B, A+C, or B+C). If more than two sections have been completed, only sections A and B will be marked
- There are 20 questions in each section.
  - Each correctly answered question is worth 1 point.
  - Each incorrectly answered question will contribute a half mark deductions (-0.5 mark off).
  - No points will be awarded or deducted for unanswered questions.
- Exam proctors may not answer questions regarding the exam material.

## Section A: Physics

1) We know that a pendulum of length  $l$  (m) and of mass  $m$  (kg) has a period of oscillation  $T$  expressed in seconds. Which of the following formulas would give you the pendulum's period of oscillation? Note that  $g = 9.8 \text{ m/s}^2$ .

- A. It's impossible to determine without experimental data.
- B.  $T = 2\pi\sqrt{\frac{l}{g}}$
- C.  $T = 2\pi\frac{l}{g}$
- D.  $T = 2\pi\sqrt{\frac{mg}{l}}$
- E.  $T = 2\pi\frac{g}{l}$

2) A 5 kg watermelon is dropped from a height that is kilometers up into the atmosphere. Its diameter is of 40 cm and is in a free fall where the only forces acting on it are weight and air friction. For small spherical objects going at low speeds ( $R < 10 \text{ mm}$ ), friction force is given by  $F_{fr} = -Cv$ . This force can be used to calculate water droplets speeds for example. For the air,  $C$  is approximately  $3.1 \times 10^{-4} \times R_{\text{radius}}$  (in SI units).

When the object is larger or is traveling at higher speeds, the friction force is given by:

$$F_{fr} = -Cv - C'v^2.$$

The second order term is so much more important than the first in these situations that the first order term can be ignored (set to 0). For the air,  $C'$  is approximately  $0.88 \times R^2_{\text{radius}}$  (in SI units). Using  $g = 9.8 \text{ m/s}^2$ , what will be the maximal speed of the watermelon in its free fall?

(Hint: Use the fact that the sum of forces acting on an object at equilibrium is zero).

- A. We cannot determine the maximal velocity from the equation
- B. 790 323 m/s
- C. 1392 m/s
- D. 790 km/s
- E. 37.3 m/s

3) Professional golfers will spend a lot of money to increase the distance they can hit a ball. An eccentric billionaire has decided to exploit this market by sending professional golfers to the moon ( $g_{\text{MOON}} = 1.62 \text{ m/s}^2$ ) for 2.5 million dollars each.

If Jeremy can hit a golf ball 300 metres when hit at  $45^\circ$  with respect to the horizontal on earth ignoring air resistance. How many more meters per dollar does Jeremy get if he hits the ball at the same angle and speed when he buys a ticket from an eccentric billionaire. ( $g_{\text{EARTH}} = 9.8 \text{ m/s}^2$ )

- A.  $3.07 \times 10^{-3} \text{ m/dollar}$

- B.  $4.93 \times 10^{-5}$  m/dollar
- C.  $6.00 \times 10^{-4}$  m/dollar
- D.  $7.29 \times 10^{-4}$  m/dollar
- E.  $6.21 \times 10^{-4}$  m/dollar

4) It is known that both the Earth and the Sun exert a force of gravitational attraction onto each other, given by  $F_G = G \frac{m_E m_S}{r^2}$ , where  $r$  is the distance between the two celestial bodies,  $m_E$  and  $m_S$  are their

respective masses and  $G$  is the gravitational constant. If Earth and the Sun are both attracting each other, why isn't Earth crashing into the Sun?

- A. Earth is in fact slowly "crashing" into the Sun, it is simply a process that will take billions of years
  - B. Earth has an initial non-zero angular speed, the Sun's attraction simply keeps the Earth spinning around it instead of letting it fly away
  - C. From Newton's third law, both the Earth and the Sun are attracting each other with the same strength, which cancels out since those vectors are in opposite directions
  - D. The force exerted by the other planets of the solar system is non-negligible and cancels out the Sun's gravitational force
  - E. The Earth is in fact flat, thus making the whole theory absurd
- 5) Which of the following associations contains an intruder?
- A. Magnitude, Direction, Vector, Scalar
  - B. Entropy, Energy, Thermos, Enthalpy
  - C. Position, Speed, Acceleration, Weight
  - D. Refraction, Distraction, Reflection
  - E. Convection, Conduction, Radiation

6) An airplane travels 300 km/h in the air. A wind from the west moves 40 km/h. Find the velocity of the plane relative to the ground if the plane travels [S35°W]

- A. 279 km/h [S23°W]
- B. 279 km/h [N7.6°E]
- C. -279 km/h [S23°W]
- D. 303 km/h [S23°W]
- E. -303 km/h [N7.6°E]

## Section B: Chemistry

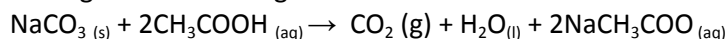
1) Derek wants to access his father's vault. The keycode to the vault is composed of a maximum of 4 digits. Derek has access to his dad's (Philip) laboratory, in which he can heat things to extremely high temperatures. He already knows there is 12.50 L of formaldehyde in a bag, and knows the pressure inside the bag is the same as the external pressure, 101.0 kPa in the room. There are  $4.020 \times 10^{22}$  molecules of formaldehyde inside the bag. If the key code is equal to the temperature in Celsius of the formaldehyde, what is the keycode?

- A. 2275
- B. 2002
- C. 2000
- D. 230
- E. 223

2) In industrial processes, excess oxygen is often pumped into combustion reactions to assure completion of the reaction and to maximize efficiency. For the complete combustion of 12.5 g of methane ( $\text{CH}_4$ ), you discover that you have 12% excess oxygen gas left over once the reaction is complete. How many moles of oxygen gas in total were added to the system?

- A. 0.873
- B. 1.17
- C. 1.75
- D. 3.12
- E. 1.59

3) Jimmy is attempting to recreate a volcano, so he grabs some chemicals from his dad's laboratory that he knows will react according to the following balanced chemical reaction:



Jimmy decides to add 5.2 g of sodium bicarbonate to 6.7 g of acetic acid. Calculate the mass of  $\text{CO}_2$  produced.

- A. 2.7 g
- B. 3.5 g
- C. 2.2 g
- D. 3.8 g
- E. Not enough information given

4) Gerald likes causing trouble. One day, he finds the keycode to his father's laboratory, in which he sees a 500 L aquarium. On the wall he notices a theoretical reaction:  $\text{A} + \text{B} \rightarrow \text{AB}$   $\Delta H_{\text{rxn}} = -925 \text{ kJ}$ . How many moles of reactant A are needed to increase the ambient temperature of his dad's fish tank from the starting  $20^\circ\text{C}$  to  $100^\circ\text{C}$ . Assume specific heat capacity of  $\text{H}_2\text{O (l)}$  to be  $4.186 \text{ J/g}^\circ\text{C}$ .

- A. 2.83 mol
- B. 5.83 mol
- C. 181.32 mol
- D. 185.54 mol
- E. Not enough information given

5) In chemistry, molecules adopt particular atomic arrangements. It is the molecular structure that allows us to determine important properties of a molecule, such as its polarity, its reactivity and even its biological activity.

Molecular structures are particularly governed by the geometry of electron groups. Electron groups position themselves around the center atom in a way to minimize repulsion and maximize attraction:

- For two electron groups, the molecule adopts a linear geometry.
- For three electron groups, the molecule adopts a trigonal-planar geometry.
- For four electron groups, the molecule adopts a tetrahedral geometry.

What are the geometries of  $\text{SO}_3$ ,  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ , and  $\text{PO}_4^{3-}$  ?

- A. Trigonal-planar, linear, linear, tetrahedral.
- B. Trigonal-planar, linear, tetrahedral, tetrahedral.
- C. Tetrahedral, linear, linear, trigonal-planar.
- D. Trigonal-planar, linear, tetrahedral, trigonal-planar.
- E. Trigonal-planar, linear, linear, trigonal-planar.

6) A 3 L bottle is half full and contains dihydrogen tetroxysulfate ( $\text{H}_2\text{SO}_4$ ) at 3.2 M. How many ions of hydrogen are there in the solution?

- A.  $2,98 \times 10^{23}$  atoms
- B.  $5,78 \times 10^{24}$  atoms
- C.  $1,45 \times 10^{23}$  atoms
- D.  $2,90 \times 10^{24}$  atoms
- E.  $7,65 \times 10^{23}$  atoms

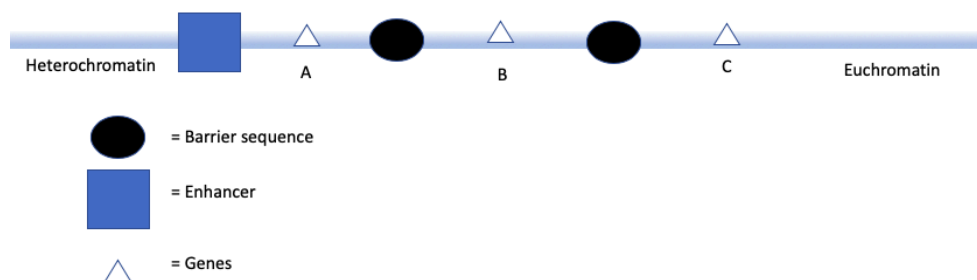


## Section C: Biology

1) If you isolate mitochondria and place them in a buffer with a low pH they begin to make ATP. Why?

- A. In a buffer, isolated mitochondria are directly exposed to high concentrations of oxygen.
- B. The low pH of the buffer causes an increase in protons in the intermembrane space of the isolated mitochondria, leading to ATP production by ATP synthase.
- C. The low pH of the buffer causes a release of OH<sup>-</sup> by the isolated mitochondria, which is directly coupled to ATP synthesis by the ATP synthase.
- D. The low pH of the buffer causes stress to the mitochondrial outer membrane, which activates the ATP synthase.
- E. ATP synthase is soluble in the buffer and so it can now synthesize ATP.

2) Heterochromatin is tightly packed DNA which suppresses the activity of a gene, which can spread. Euchromatin is lightly packed and is enriched in genes. Barriers are specific DNA sequences which mark the borders of heterochromatic regions, preventing it from spreading. An enhancer is a DNA sequence which increases the level of transcription of a gene. Knowing this, and knowing transcription can go in either direction, which of the following genes will be expressed the most?



- A. Gene A
- B. Gene B
- C. Gene C
- D. Gene B and C
- E. None of the above

3) There are many types of mutations that DNA can be subjected to. Of these mutations, frameshift mutations often lead to the worst consequences because it, as the name suggests, shifts the reading frame which is especially important for protein synthesis. Which nucleotide sequence is a frameshift mutation if the coding strand is 3'-ATGGCTTCGATCTCTCA-5' ?

- A. 5'-UGAGAGAUCCAAGCAAU-3'
- B. 5'-TGAGAGATCGAATCTAT-3'
- C. 5'-ATGGCTTCGATCTCTAA-3'
- D. 5'-TGAGAGATCGAAGCAAT-3'
- E. 5'-TGAGAGATTCCAAGCCAT-3'

4) Nutrient turnover rate is very high in tropical environments and there is often very great competition for both space and nutrients. Knowing this, why do trees in the rainforest often have shallow but wide root systems, whereas trees in temperate climates usually have deeper root systems?

- A. Tropical climates often have more moisture in the soil, shallow and wide root systems give trees more stability
- B. High nutrient turnover rate means that nutrients are mostly concentrated in the upper layers of soil. Shallow and wide root systems allow tropical trees to take advantage nutrients are located at the upper layers of soil
- C. Tropical environments are often hot and muggy. Shallow and wide root systems keep the tree cool in hot climates
- D. Since there is strong competition, shallow and wide root systems allow tropical trees to stake their territory
- E. Temperate climates have cold winters so trees with deeper roots allow them to avoid freezing during the winter

5) The following term describes a large and stressful event that causes a significant decrease in a population, leaving only a few individuals:

- A. Genetic drift
- B. Bottleneck effect
- C. Founder effect
- D. Natural selection
- E. Cladogenesis

6) Which of the following statements is FALSE:

- A. A dipeptide is two amino acid residues joined together.
- B. An oligopeptide is formed of many amino acid residues.
- C. Adenine and guanine are bases found in DNA and RNA.
- D. Thymine is a base found in DNA.
- E. Nucleosides are formed of a base and a sugar

**Answers:**

**Section A: Physics**

- 1) C
- 2) E
- 3) C
- 4) B
- 5) D
- 6) A

**Section B: Chemistry**

- 1) B
- 2) C
- 3) C
- 4) C
- 5) B
- 6) B

**Section C: Biology**

- 1) B
- 2) D
- 3) E
- 4) B
- 5) B
- 6) B