

## Round 1

### 1. EARTH and SPACE

Writer: Nicholas Parker Ng

Toss Up: Multiple Choice

Which of these is till?

- W) fine flacial lake clay
- X) well-sorted outwash sand
- Y) a polished rock outcrop
- Z) unsorted sand, gravel, and clay in a moraine

Toss Up Answer: Z

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Bonus: Short Answer

How many officially recognized dwarf planets are there in our solar system?

Bonus Answer: 5

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### 2. MATHEMATICS

Writer: Steven Litvack-Winkler

Toss Up: Short Answer

Find  $x/y + y/x$  in simplest form if  $x=7$  and  $y=3$

Bonus Answer: 58/21

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Bonus: Short Answer

Positive integers  $a$  and  $b$  satisfy  $ab \mid a^2 + 4ab + 4b^2$  [" $a$   $b$  divides  $a$  squared plus four  $a$   $b$  plus four  $b$  squared"]. The smallest possible value of  $a+b$  is 2, which occurs when  $a=b=1$  [" $a$  equals  $b$  equals 1"]. What is the second smallest possible value of  $a+b$ ?

Bonus Answer: 6:  $a=4$ ,  $b=2$

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### 3. CHEMISTRY

Writer: Nicholas Parker Ng

Toss Up: Multiple Choice

Radiation from a mercury lamp source is of energy 2.845 eV. Calculate the wavelength of the radiation.

- W) 579 nm
- X) 355 nm
- Y) 405 nm
- Z) 436 nm

Toss Up Answer: Z

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Bonus: Multiple Choice

The force constant of the bond in a hydrogen chloride, HCl, molecule is  $516 \text{ N m}^{-1}$ . Calculate the vibrational potential energy of an HCl molecule with a bond that is extended from its equilibrium length by  $0.11 \text{ \AA}$ .

- W)  $3.1 \times 10^{-20} \text{ J}$
- X)  $6.2 \times 10^{-20} \text{ J}$
- Y)  $1.5 \times 10^{-20} \text{ J}$
- Z)  $2.6 \times 10^{-20} \text{ J}$

Bonus Answer: W

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### 4. EARTH and SPACE

Writer: Nicholas Parker Ng

### **Toss Up: Multiple Choice**

The "firn line" on a glacier marks:

- W) The dividing line between the zones of accumulation and ablation
- X) The elevation above which snow never melts
- Y) The elevation where the average annual temperature is below freezing
- Z) The timber line, or elevation above which trees do not grow

**Toss Up Answer: W**

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### **Bonus: Short Answer**

During the Pleistocene, large lakes covered parts of the Western U.S. These lakes are known as:

**Bonus Answer: Pluvial lakes**

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## **5. MATHEMATICS**

**Writer: Steven Litvack-Winkler**

### **Toss Up: Multiple Choice**

For real numbers  $x$  and  $y$  on the closed interval from 0 to 1, let  $a=xy$  and  $b=(1-x)(1-y)$ . Find the maximum value over all choices of  $x$  and  $y$  for the minimum of  $a$  and  $b$ .

- W) 0
- X)  $1/4$
- Y)  $1/2$
- Z) 1

**Toss Up Answer: X**

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### **Bonus: Short Answer**

One definition of the Cantor set is the set of all numbers  $x$  between 0 and 1 such that  $x$  has only the digits 0 and 2 in it's base 3 representation. Which of the following numbers is in the Cantor set.

- I.  $1/4$
- II.  $1/2$
- III.  $5/26$
- IV.  $7/10$

**Bonus Answer: 4 only**

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## **6. BIOLOGY**

**Writer: Olivia Gallager**

### **Toss Up: Short Answer**

Out of the following, by name or number, which are considered gram positive: Influenza, Bacillus Anthracis, Escherischia Coli, and Bordetella Pertussis

**Bonus Answer: 2, Bacillus Anthracis**

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### **Bonus: Short Answer**

What is the main immunoglobulin found in mucous secretions?

**Bonus Answer: IgA, immunoglobulin A**

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## **7. PHYSICS**

**Writer: Charles Zhang**

### **Toss Up: Short Answer**

What is the unit of the quantity  $1/(4\pi\epsilon_0)$  (READ AS: 1 over 4 times Pi times epsilon naught)?

**Bonus Answer:  $N\cdot m^2/C^2$  (READ AS: newton meters squared over coulomb squared)**

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**Bonus: Short Answer**

An time-varying electric field is given by  $(24t^2 \text{ N/C})\mathbf{i} + (30t \text{ N/C})\mathbf{j} + (16/t \text{ N/C})\mathbf{k}$ . What is its flux at time  $t=2$  as it passes through a region in the  $y$ - $z$  plane whose area is given by  $A(t)=2t$ ?

**Bonus Answer: 112 N/C**

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**8. BIOLOGY**

**Writer: Olivia Gallager**

**Toss Up: Short Answer**

Bob's mother had Cystic Fibrosis, and his father was a carrier, but Bob is unaffected. If Cynthia's parents were both carriers of Cystic Fibrosis, then what is the probability, expressed as a simple fraction, of Bob and Cynthia having a child with CF?

**Bonus Answer: 1/8**

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**Bonus: Multiple Choice**

Marfan's Syndrome exhibits which Mendelian inheritance pattern?

- W) Abe Lincoln
- X) X-linked recessive
- Y) Autosomal Recessive
- Z) Autosomal Dominant

**Bonus Answer: Z**

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**9. CHEMISTRY**

**Writer: Nicholas Parker Ng**

**Toss Up: Multiple Choice**

The hydrolysis of t-bromobutane,  $\text{C}_4\text{H}_9\text{Br}$ , by hydroxide,  $\text{OH}^-$ , ions in aqueous solution follows an  $\text{SN}_1$  reaction mechanism in which the rate-determining step is the loss of a bromide,  $\text{Br}^-$ , ion, followed by rapid reaction with hydroxide ions. Which of the following rate laws is consistent with this mechanism?

- W)  $\text{Rate} = k[\text{C}_4\text{H}_9\text{Br}]$
- X)  $\text{Rate} = k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]$
- Y)  $\text{Rate} = k[\text{C}_4\text{H}_9\text{Br}]^2$
- Z)  $\text{Rate} = k[\text{OH}^-]$

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

Which of the following would be correct units for the rate constant of a reaction that is second order overall?

- W)  $\text{s}^{-1}$
- X)  $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$
- Y)  $\text{mol cm}^{-3} \text{s}^{-1}$
- Z)  $\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$

**Bonus Answer: X**

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**10. MATHEMATICS**

**Writer: Steven Litvack-Winkler**

**Toss Up: Multiple Choice**

Triangle ABC is similar to triangle DEF. If triangle ABC has an area of 27, triangle DEF has an area of 3, and  $AC=12$ , then compute DF.

- W) 9

- X) 36
- Y)  $2\sqrt{3}$
- Z) 4

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

What is the area, in terms of pi, of a cone if the slant height is 13 and the radius of the base is 5.

- W) 10 pi
- X) 20 pi
- Y) 30 pi
- Z)  $10\sqrt{3}$  pi + 20

**Bonus Answer: X**

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## 11. PHYSICS

**Writer: Charles Zhang**

**Toss Up: Multiple Choice**

A wheel starts from rest and has an angular acceleration that is given by  $\alpha(t) = (6 \text{ rad/s}^4)t^2$  (READ AS: 6 radians per seconds to the fourth times t squared). What is the angle the wheel turns through after time t?

- W)  $[(1/8)t^4] \text{ rad}$
- X)  $[(1/4)t^4] \text{ rad}$
- Y)  $[(1/2)t^4] \text{ rad}$
- Z)  $[t^4] \text{ rad}$

**Toss Up Answer: Y**

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**Bonus: Short Answer**

String is wrapped around the periphery of a 5.0-cm radius cylinder, free to rotate on its axis. The string is pulled straight out at a constant rate of 10 cm/s and does not slip on the cylinder. As each small segment of string leaves the cylinder, what does its acceleration change by?

**Bonus Answer:  $0.2 \text{ m/s}^2$**

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## 12. MATHEMATICS

**Writer: Ashneel Das**

**Toss Up: Multiple Choice**

Which of the following best describes the roots of the function  $f(x) = x^2 + 4x + 6$

- W) Real and Equal
- X) Real and Unequal
- Y) Complex and equal
- Z) Complex and unequal

**Toss Up Answer: Z**

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**Bonus: Short Answer**

If  $f(x) = 2x^2 + 6x + 12$ , what is  $f'(x)$ ?

**Bonus Answer:  $4x + 6$**

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## 13. PHYSICS

**Writer: Charles Zhang**

**Toss Up: Multiple Choice**

If a wheel is turning at  $3.0/\pi \text{ rad/s}$ , what is its period?

- W) 3.14
- X) 6.58
- Y) 8.73
- Z) 9.67

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

What is the total energy of a block attached to a spring with spring constant of 50 N/m if the block's velocity corresponds to the equation,  $v(t) = 10\sin(2t)$  (READ AS:  $v$  of  $t$  equals 10 times sin of quantity  $2t$ )?

- W) 100 J
- X) 125 J
- Y) 250 J
- Z) 500 J

**Bonus Answer: X**

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## 14. CHEMISTRY

**Writer: Nicholas Parker Ng**

**Toss Up: Multiple Choice**

The longest wavelength absorption in the UV visible spectrum of acetone,  $\text{CH}_3\text{COCH}_3$ , occurs at 335 nm. Predict the energy required to excite an electron from a lone pair orbital on the oxygen atom to an antibonding orbital centred on the carbonyl group.

- W) 3.7 eV
- X) .27 eV
- Y) 2.99 eV
- Z) 1.67 eV

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

The Pauling electronegativities of fluorine and chlorine are 4.0 and 3.0 respectively. Estimate the dipole moment of chlorine monofluoride, ClF.

- W) 4 D
- X) 3 D
- Y) 1.6 D
- Z) 1 D

**Bonus Answer: Z**

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## 15. PHYSICS

**Writer: Charles Zhang**

**Toss Up: Short Answer**

Assume that Earth is in circular orbit around the Sun with kinetic energy  $K$  and potential energy  $U$ , taken to be zero for infinite separation. What is the relationship between  $K$  and  $U$ ?

**Bonus Answer:  $K = -U/2$  (accept equivalent forms)**

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**Bonus: Multiple Choice**

A planet is in circular orbit around the Sun. Its distance from the Sun is four times the average distance of Earth from the Sun. The period of this planet, in Earth years, is:

- W) 4
- X) 8
- Y) 16
- Z) 64

**Bonus Answer: X**

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## 16. CHEMISTRY

**Writer: Nicholas Parker Ng**

**Toss Up: Multiple Choice**

In which of the lists below are the atoms arranged in order of increasing size (increasing atomic radius)?

- W) Si In Ge N
- X) N In Ge Si
- Y) In Ge N Si
- Z) N Si Ge In

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

Which of the following matched pairs of name and formula has an error?

- W) H<sub>3</sub>PO<sub>4</sub>, phosphoric acid
- X) H<sub>2</sub>SO<sub>3</sub>, sulfurous acid
- Y) HNO<sub>3</sub>, nitrous acid
- Z) HClO<sub>4</sub>, perchloric acid

**Bonus Answer: Y**

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## 17. EARTH and SPACE

**Writer: Nicholas Parker Ng**

**Toss Up: Multiple Choice**

A stream can lengthen its channel by:

- W) hydraulic action
- X) headward erosion
- Y) downcutting
- Z) vertical accretion

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

In uniform flat rocks, drainage patterns are typically

- W) Radial
- X) dendritic
- Y) trellis
- Z) braided

**Bonus Answer: X**

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## 18. CHEMISTRY

**Writer: Nicholas Parker Ng**

**Toss Up: Multiple Choice**

Identify the INCORRECT statement below:

- W) In the most fundamental sense, the properties of the elements are periodic functions of their atomic weight.
- X) The vertical columns of the periodic chart are called groups, sharing similar properties.
- Y) Elements with atomic numbers of 9, 17, 35, and 53 are members of the halogen family, meaning "salt formers."
- Z) Elements Li, B, N and F are all in the same period.

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

All of the following statements are true EXCEPT:

- W) the enthalpy change of an endothermic reaction is positive.
- X) at constant pressure the heat flow for a reaction equals the change in enthalpy.
- Y)  $\Delta H$  for a reaction is equal in magnitude but opposite in sign to  $\Delta H$  for the reverse reaction.
- Z) enthalpy change is dependent upon the number of steps in a reaction.

**Bonus Answer: Z**

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## 19. BIOLOGY

**Writer: Ahmad Alnasser**

**Toss Up: Multiple Choice**

The structure of bone tissue suits the function. Which of the following bone tissues is adapted to support weight and withstand tension stress?

- W) Spongy bone
- X) Irregular bone
- Y) Compact bone
- Z) Trabecular bone

**Toss Up Answer: Y**

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**Bonus: Short Answer**

Which hormone increases osteoclast activity to release more calcium ions into the bloodstream?

**Bonus Answer: Parathyroid Hormone**

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## 20. PHYSICS

**Writer: Andrew Zheng**

**Toss Up: Multiple Choice**

An artificial satellite orbiting Earth above North America releases a bomb. Neglecting air resistance, the bomb will do which one of the following?

- W) strike North America at the instant of release
- X) strike China at the instant of impact
- Y) never strike Earth
- Z) strike China at the instant of release

**Toss Up Answer: Y**

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**Bonus: Short Answer**

In planetary motion the line from the star to the planet sweeps out equal areas in equal times. This is a direct consequence of which law?

**Bonus Answer: law of conservation of angular momentum (DO NOT ACCEPT Kepler's Second Law)**

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## 21. BIOLOGY

**Writer: Ahmad Alnasser**

**Toss Up: Short Answer**

Both fungus-farming ants and their fungi can synthesize the same structural polysaccharide from the  $\beta$ -glucose. What is this polysaccharide?

**Bonus Answer: Chitin**

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**Bonus: Short Answer**

Plasmogamy can directly result in which of the following? 1. cells with a single haploid nucleus 2. heterokaryotic cells 3. dikaryotic cells 4. cells with two diploid nuclei

**Bonus Answer: 2 and 3**

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**22. BIOLOGY**

**Writer: Shanjeed Ali**

**Toss Up: Multiple Choice**

Carpal tunnel syndrome is caused by

- W) wear of cartilage in the wrist
- X) stress in the lateral epicondyle
- Y) pressure on the median nerve
- Z) partial tear of the extensor digitorum

**Toss Up Answer: Y**

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**Bonus: Multiple Choice**

Which of the following has not been shown to increase the likelihood of carpal tunnel syndrome?

- W) obesity
- X) repetitive wrist motion
- Y) rheumatoid arthritis
- Z) hyperextension

**Bonus Answer: Z**

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**23. BIOLOGY**

**Writer: Jason Weng**

**Toss Up: Short Answer**

What is the process of removing the base of a nucleotide?

**Bonus Answer: Depurination**

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**Bonus: Short Answer**

Out of the 3, which of them uses an electron transport system: fermentation, anaerobic respiration, aerobic respiration

**Bonus Answer: anaerobic respiration, aerobic respiration (2,3)**

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**24. BIOLOGY**

**Writer: Olivia Gallager**

**Toss Up: Multiple Choice**

Which of the following describes the inheritance pattern of Huntingtons Disease?

- W) Autosomal Recessive
- X) X Linked Recessive
- Y) Y linked
- Z) Autosomal dominant

**Toss Up Answer: Z**

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**Bonus: Short Answer**

Cystic fibrosis is a genetic disease that affects the lungs and other mucus membranes through the absence or deformation of certain ion channels. Which ion do these channels allow to flow, in people without cystic fibrosis?

**Bonus Answer: Chloride, accept chlorine**

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**25. BIOLOGY**

**Writer: Ahmad Alnasser**

**Toss Up: Multiple Choice**

If all fungi in an environment that perform decomposition were to suddenly die, then which group of organisms should benefit most, due to the fact that their fungal competitors have been removed?

W) Prokaryotes

X) Plants

Y) animals

Z) fungi

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

When a mycelium infiltrates an unexploited source of dead organic matter, what are most likely to appear within the food source soon thereafter?

W) sores

X) fungal enzymes

Y) fungal haustoria

Z) larger bacterial populations

**Bonus Answer: X**

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