

## Round 4

### 1. PHYSICS

Writer: Charles Zhang

Toss Up: Multiple Choice

A wave's equation is given as  $y = 0.1 \sin(3x + 10t)$  (READ AS: y equals 0.1 times sine of open parentheses 3x plus 10t close parentheses). What is the angular wave number?

W) 0.3

X) 1

Y) 10

Z) 3

Toss Up Answer: Z

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Bonus: Short Answer

An EM wave has a magnetic field with an amplitude of 200 Teslas. What is the amplitude of the wave's electric field in N/c (READ AS: newtons per coulomb)?

Bonus Answer:  $6 \times 10^{10}$  N/c

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### 2. PHYSICS

Writer: Charles Zhang

Toss Up: Multiple Choice

The sound intensity 3.0m from a point source is  $22 \text{ W/m}^2$  (READ AS: 25 watts per meter squared). The power output of the source is:

W) 53

X)  $396\pi$

Y) 168

Z)  $300\pi$

Toss Up Answer: X

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Bonus: Short Answer

A string has length L and mass M. If its fundamental frequency is f, find its tension in terms of L, M and f.

Bonus Answer:  $4LMf^2$  (READ AS: 4 times L times M times f squared)

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### 3. PHYSICS

Writer: Charles Zhang

Toss Up: Short Answer

The coefficient of linear expansion of a certain steel is 0.000034 per  $^\circ\text{C}$  (READ AS: celsius degree). What is the exact coefficient of volume expansion, in  $(^\circ\text{C})^{-1}$  (READ AS: celsius degree to the negative 1)?

Bonus Answer: 0.000102 (DO NOT ACCEPT APPROXIMATIONS)

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Bonus: Multiple Choice

The energy given off as heat by 300 g of an alloy as it cools through  $50^\circ\text{C}$  (READ AS: 50 celsius degree) raises the temperature of 300 g of water from  $30^\circ\text{C}$  (READ AS: 30 degrees celsius) to  $40^\circ\text{C}$ . The specific heat of the alloy (in  $\text{cal/g} \cdot ^\circ\text{C}$ ) is:

W) 0.0015

X) 0.1

Y) 0.2

Z) 1

Bonus Answer: Y

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## 4. PHYSICS

Writer: Yevgeniy Gorbachev

Toss Up: Short Answer

If a rocket has a specific impulse of 800 seconds, what is its exhaust velocity, in m/s? Assume standard gravity to be  $10 \text{ m/s}^2$ .

**Bonus Answer:** Answer: 8000 m/s (also acceptable: 8 km/s). Exhaust velocity is the product of specific impulse as a unit of time and standard gravity.

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**Bonus: Short Answer**

If an engine has a specific impulse of 500 seconds and a thrust of 10 kN, how long will it take the engine to burn 50 kg of fuel? Assume standard gravity to be  $10 \text{ m/s}^2$ .

**Bonus Answer:** Answer: 25 seconds.

Since  $F_{\text{thrust}} = G_{\text{standard}} \times I_{\text{sp}} \times R$ , where

$F_{\text{thrust}}$  = instantaneous thrust of the engine (in newtons)

$G_{\text{standard}}$  = standard gravity (usually  $9.81 \text{ m/s}^2$ , but for simplicity we round to 10)

$I_{\text{sp}}$  = specific impulse of the engine in seconds

$R$  = mass flow rate in kg/s

$10000 = 10 \times 500 \times R$ , so  $R = 2 \text{ kg/s}$

$50 \text{ kg} / 2 \text{ kg/s} = 25 \text{ s}$

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## 5. MATHEMATICS

Writer: Hussain Waris

Toss Up: Multiple Choice

A set is countable:

W) If and only if it is finite.

X) If and only if a surjection can be made between the set and the natural numbers.

Y) If it has the same cardinality as some subset of the natural numbers.

Z) If it has the same cardinality as some subset of the real numbers.

**Toss Up Answer:** Y

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**Bonus: Short Answer**

Who was the famous German mathematician that invented Set Theory and effectively proved the uncountableness of the reals?

**Bonus Answer:** Georg Cantor (accept Cantor)

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## 6. MATHEMATICS

Writer: Andrew Chen (Senior)

Toss Up: Multiple Choice

Simplify the following expression:  $(x^3 + 27)/(x + 3)$  if  $x = 12$

W) 125

X) 117

Y) 136

Z) 109

**Toss Up Answer:** X

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**Bonus: Short Answer**

Find all the real solutions of  $x^4 - 18 = -2$

**Bonus Answer:**  $x = 2$ ,  $x = -2$

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## 7. MATHEMATICS

Writer: Andrew Chen (Senior)

Toss Up: Short Answer

What is the sum of the interior angles of a nonagon?

Bonus Answer: 1260 degrees

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Bonus: Short Answer

How many edges does an octahedral prism have?

Bonus Answer: 24 edges

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## 8. MATHEMATICS

Writer: Jessica Titensky

Toss Up: Short Answer

Convert CD from hexadecimal to decimal

Bonus Answer: 205

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Bonus: Short Answer

Convert CD from hexadecimal to binary

Bonus Answer: 11001101

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## 9. BIOLOGY

Writer: Nten Nylam

Toss Up: Short Answer

What is it called when a species of animal becomes two separate species while inhabiting the same area?

Bonus Answer: Sympatric speciation

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Bonus: Multiple Choice

Cladograms are used to determine?

W) Taxonomy

X) Geographic Distribution

Y) Genotype

Z) Evolutionary relatedness

Bonus Answer: Z

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## 10. BIOLOGY

Writer: Jason Weng

Toss Up: Short Answer

What substance protects the stomach from consuming itself?

Bonus Answer: Mucus

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Bonus: Multiple Choice

In which organs is thrombopoietin produced?

W) Heart and Liver

X) Liver and Kidney

Y) Kidney and Pancreas

Z) Pancreas and Liver

Bonus Answer: X

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## 11. BIOLOGY

Writer: Jason Weng

Toss Up: Short Answer

Which glial cells secrete cerebrospinal fluid?

**Bonus Answer: Ependymal cells**

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**Bonus: Short Answer**

Oxygen attaches to hemoglobin to form oxyhemoglobin. What is the resultant molecule called when carbon dioxide attaches to hemoglobin?

**Bonus Answer: Carbaminohemoglobin**

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## 12. BIOLOGY

Writer: Jason Weng

Toss Up: Short Answer

What organelle does the cisternal maturation model describe?

**Bonus Answer: Golgi apparatus; Golgi complex**

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**Bonus: Short Answer**

What is the part on the retina where cones are tightly packed and creates a small depression?

**Bonus Answer: Fovea; Fovea centralis**

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## 13. BIOLOGY

Writer: Jason Weng

Toss Up: Short Answer

What functional group normally allows the cell to differentiate old and new DNA strands in prokaryotes?

**Bonus Answer: Methyl group; -CH<sub>3</sub>**

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**Bonus: Short Answer**

What is it called when the hematocrit rises above normal levels?

**Bonus Answer: hypercythemia; erythrocythemia; hypererythrocythemia**

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## 14. BIOLOGY

Writer: Jason Weng

Toss Up: Short Answer

What hormone released by juxtaglomerular cells of the kidney regulates blood pressure and filtration rate?

**Bonus Answer: Renin**

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**Bonus: Short Answer**

What types of exocrine glands bud their secretions off along with a small portion of the cell itself?

**Bonus Answer: Apocrine glands**

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## 15. BIOLOGY

Writer: Jason Weng

Toss Up: Short Answer

What types of cells in the stomach are pepsins produced from?

**Bonus Answer: Chief cells**

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**Bonus: Short Answer**

What factor of the blood clotting cascade converts prothrombin into active thrombin?

**Bonus Answer: Factor III; Tissue Factor; Thromboplastin**

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## 16. BIOLOGY

Writer: Hanna Yang

Toss Up: Multiple Choice

Which of the following is a retrovirus?

W) HIV

X) Hepatitis B virus

Y) Poliovirus

Z) Influenza A virus

Toss Up Answer: W

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Bonus: Short Answer

Where do DNA viruses usually replicate?

Bonus Answer: In the nucleus.

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## 17. BIOLOGY

Writer: Hanna Yang

Toss Up: Multiple Choice

Which of the following is present in plant cells but not animal cells?

W) Nuclei

X) Plasmodesmata

Y) Mitochondria

Z) Vacuoles

Toss Up Answer: X

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Bonus: Short Answer

What is the name of the theory that explains the existence of mitochondria (and why they have their own DNA)?

Bonus Answer: Endosymbiotic Theory

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## 18. CHEMISTRY

Writer: Andrew Chen (Senior)

Toss Up: Multiple Choice

When 50 mL of stock solution of 6M NaCl (aq) is diluted into a 150 mL solution what will be the molarity of the diluted solution?

W) 3M

X) 2M

Y) 1M

Z) 6M

Toss Up Answer: X

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Bonus: Short Answer

What is the given equation for calculating molarity?

Bonus Answer: Moles of solute divided by liters of solution

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## 19. CHEMISTRY

Writer: Andrew Chen (Senior)

Toss Up: Multiple Choice

Given the following ions, Na<sup>+</sup>, Br<sup>-</sup>, Ag<sup>+</sup>, and Cu<sup>2+</sup> which ion has the greatest atomic radius?

W) Na<sup>+</sup>

X) Br<sup>-</sup>

- Y) Ag<sup>+</sup>  
Z) Cu<sup>2+</sup>

**Toss Up Answer: Y**

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**Bonus: Short Answer**

Name the group of elements with the least electronegativity.

**Bonus Answer: Noble gases (Group 18)**

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**20. CHEMISTRY**

**Writer: Andrew Chen (Senior)**

**Toss Up: Multiple Choice**

Choose the strongest acid from the choices below.

- W) Hydrochloric acid  
X) Hydrobromic acid  
Y) Hydroiodic acid  
Z) Hydrofluoric acid

**Toss Up Answer: Y**

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**Bonus: Short Answer**

What are the conjugate bases of HCl, HBr, and HI?

**Bonus Answer: Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>**

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**21. CHEMISTRY**

**Writer: Andrew Chen**

**Toss Up: Multiple Choice**

From what two molecules is an ester synthesized?

- W) alcohol and ester  
X) alcohol and aldehyde  
Y) carboxylic acid and ester  
Z) carboxylic acid and alcohol

**Toss Up Answer: Z**

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**Bonus: Short Answer**

If one mole of an acid is dissolved in a liter of water, and the acid has a pK<sub>a</sub> of 10, what is the pH of the solution?

**Bonus Answer: 7**

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**22. CHEMISTRY**

**Writer: Andrew Chen**

**Toss Up: Multiple Choice**

Which of the following exhibits diamagnetism?

- W) bronze  
X) water  
Y) liquid oxygen  
Z) diamond

**Toss Up Answer: X**

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**Bonus: Short Answer**

Order the following by second ionization energy, from lowest to highest: Sodium, Magnesium, Aluminum

**Bonus Answer: Magnesium, Aluminum, Sodium**

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## 23. EARTH and SPACE

Writer: Andrew Chen (Senior)

Toss Up: Multiple Choice

Glaciers effect the land through glacial erosion. Different geographies are formed but what is the specific name of the long narrow ridges that show where the glacier was once present?

W) Glacial retreat

X) Drumlins

Y) Glacial erotics

Z) Morianes

Toss Up Answer: Z

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Bonus: Short Answer

Ice sheets and glaciers expanded to cover large areas of land during the last major glacial epoch. During which time period did this take place?

Bonus Answer: Quaternary

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## 24. EARTH and SPACE

Writer: Andrew Chen (Senior)

Toss Up: Multiple Choice

Sedimentary rocks are formed from accumulation of different sediments. What is the term for a rock made by living organisms or composed of materials from life forms?

W) Conglomerate

X) Evaporites

Y) Crystalline

Z) Bioclastic

Toss Up Answer: Z

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Bonus: Short Answer

Give the following classifications for these sedimentary rocks, breccia, conglomerate, and shale.

Bonus Answer: All Clastic sedimentary rocks.

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## 25. EARTH and SPACE

Writer: Jessica Titensky

Toss Up: Multiple Choice

What is the closest star to earth

W) Sirius

X) Betelgeuse

Y) Alpha proxima

Z) The sun

Toss Up Answer: Z

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Bonus: Short Answer

What is the closest star to the sun

Bonus Answer: Proxima centauri

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