

## Round 5

### 1. EARTH and SPACE

Writer: Jan Wojcik

Toss Up: Multiple Choice

Which of the following is NOT true regarding cirrus clouds?

- W) They are typically found between 10,000 feet and 15,000 feet above sea level
- X) They can be formed from any cloud that goes under glaciation
- Y) They cover 25% of the Earth and have a heating effect
- Z) They have been seen forming on other planets such as Mars and Jupiter

Toss Up Answer: W

---

Bonus: Multiple Choice

The most common cloud source for a majority of tornadoes is:

- W) Cumulus
- X) Nimbostratus
- Y) Altostratus
- Z) Cumulonimbus

Bonus Answer: Z

---

### 2. MATHEMATICS

Writer: Jessica Titensky

Toss Up: Short Answer

What is  $\tan(\arcsin(9/41))$ ?

Bonus Answer: 9/40

---

Bonus: Short Answer

What is  $\sin(\operatorname{arccot}(\tan(\arccos(3/5))))$ ?

Bonus Answer: 3/5

---

### 3. BIOLOGY

Writer: Josh Tish

Toss Up: Multiple Choice

If a gene is fixed in a population:

- W) the gene cannot undergo mutation
- X) one allele exhibits complete dominance over the other allele of that gene
- Y) only one allele appears for that gene in the population
- Z) the gene is incapable of recombination

Toss Up Answer: Y

---

Bonus: Multiple Choice

The Species-Area Relationship suggests that 10% of a given area supports:

- W) 90% of species
- X) 70% of species
- Y) 50% of species
- Z) 30% of species

Bonus Answer: Y

---

## 4. EARTH and SPACE

Writer: Shamaul Dilmohamed

Toss Up: Short Answer

Which planet has the slowest rotation?

Bonus Answer: Venus

---

Bonus: Multiple Choice

Which planet has the fastest rotation?

- W) Jupiter
- X) Saturn
- Y) Uranus
- Z) Neptune

Bonus Answer: W

---

## 5. BIOLOGY

Writer: Josh Tish

Toss Up: Short Answer

You perform a transformation and calculate a viable count of 9000 cells/mL. If your transformation efficiency was 10%, how many colonies would you expect to see if you plate 100uL of cells onto selective media?

Bonus Answer: 90

---

Bonus: Short Answer

If the mother of a child suffers from diabetes mellitus and deafness (DAD) and the father does not, what is the likelihood that the child will develop degenerative optomosis?

\*Note: Diabetes mellitus and deafness (DAD) is a genetic disorder, not separate ailments.

Bonus Answer: 100%. DAD is caused by mutations in mtDNA, which are passed on only by the mother.

---

## 6. CHEMISTRY

Writer: Prangon Ghose

Toss Up: Multiple Choice

What is the correct term(s) used to determine if a system has come to equilibrium?

- W) Ka and Q
- X) Ksp
- Y) Q
- Z) Kc

Toss Up Answer: Y

---

Bonus: Multiple Choice

Chemical equilibrium may be used to describe

- W) gas phase chemical reactions
- X) acid and based ionization
- Y) Solubility
- Z) All of the Above

Bonus Answer: Z

---

## 7. BIOLOGY

**Writer: Josh Tish**

**Toss Up: Multiple Choice**

The initial frequency of allele A is 0.6, and the initial frequency of allele a is 0.4. In the next generation, the frequencies for alleles change to 0.61 and 0.39, respectively for each allele. The change in allele frequency is:

- W) the result of random mating
- X) evolution
- Y) the result of natural selection
- Z) impossible in a small population

**Toss Up Answer: X**

---

**Bonus: Multiple Choice**

What is the main structure that connects the left and right hemispheres of the brain?

- W) corpus callosum
- X) thalamus
- Y) superior colliculus
- Z) amygdala

**Bonus Answer: W**

---

**8. PHYSICS**

**Writer: Charles Zhang**

**Toss Up: Multiple Choice**

A hose has a diameter of 2 inches and its nozzle is 0.2 inches in radius. If water flows at 4 m/s in the hose, then how fast will it leave the nozzle?

- W) 4 m/s
- X) 1 m/s
- Y) 100 m/s
- Z) 200 m/s

**Toss Up Answer: Y**

---

**Bonus: Short Answer**

To measure moderately low pressures, oil with a density of  $8.5 \times 10^2 \text{ kg/m}^3$  (READ AS: 8.5 times 10 to the -2 kilogram per cubic meter) is used in place of mercury in a barometer. If the height of the oil column changes by 1.0mm, find the change in the pressure, assuming  $g = 10 \text{ m/s}^2$ .

**Bonus Answer: 8.5 Pa**

---

**9. BIOLOGY**

**Writer: Josh Tish**

**Toss Up: Multiple Choice**

Mutation in which of the following types of genes is least likely to result in higher chances of developing cancer?

- W) oncogene
- X) tumor suppressor gene
- Y) proto-oncogene
- Z) tumor necrosis factor gene

**Toss Up Answer: Z**

---

**Bonus: Short Answer**

Rearrange the following list of the structures of a nephron in the order in which filtrate flows through them:

1. proximal convoluted tubule
2. ascending limb of Loop of Henle
3. distal convoluted tubule
4. collecting duct
5. Bowman's capsule
6. descending limb of Loop of Henle

**Bonus Answer:** 5, 1, 6, 2, 3, 4

**\*A list of the structures or the correct reordering of the numbers assigned to each structure are valid answers**

=====

## 10. MATHEMATICS

**Writer:** Jessica Titensky

**Toss Up:** Short Answer

What is the amplitude of  $y=4\sin(5x+3)$

**Bonus Answer:** 4

=====

**Bonus:** Short Answer

What is the period of  $y=4\sin(5x+3)$  rounded to the nearest 100th

**Bonus Answer:** 1.26

=====

## 11. BIOLOGY

**Writer:** Janine Goh

**Toss Up:** Short Answer

Which process is complementary to hydrolysis?

**Bonus Answer:** Dehydration synthesis

=====

**Bonus:** Multiple Choice

Which of the following inhibits carbonic anhydrase?

- W) Erythromycin
- X) Imipramine
- Y) Acetazolamide
- Z) Ambylmycin

**Bonus Answer:** Y

=====

## 12. CHEMISTRY

**Writer:** Prangon Ghose

**Toss Up:** Multiple Choice

The term(s) most useful in determining the solubility of a substance is (are)

- W)  $K_a$  and  $Q$
- X)  $K_{sp}$
- Y)  $Q$  and Le Chatelier's Principle
- Z)  $K_c$

**Toss Up Answer:** X

=====

**Bonus:** Multiple Choice

The effect of temperature on a chemical system is best described using

- W)  $K_a$  and  $Q$
- X)  $K_{sp}$
- Y) Le Chatelier's Principle

Z) Kc

**Bonus Answer: Y**

=====

### 13. BIOLOGY

**Writer: Janine Goh**

**Toss Up: Short Answer**

Haemoglobin alpha and beta globin chains are found in what 2 chromosomes?

**Bonus Answer: Alpha: Chromosome 16**

**Beta: Chromosome 11**

=====

**Bonus: Short Answer**

Name all types of RNA

**Bonus Answer: mRNA, tRNA, rRNA**

=====

### 14. EARTH and SPACE

**Writer: Shamaul Dilmohamed**

**Toss Up: Multiple Choice**

What is the penultimate spectral type of a star?

W) F

X) G

Y) K

Z) M

**Toss Up Answer: Y**

=====

**Bonus: Short Answer**

What spectral type is the Sun?

**Bonus Answer: G**

=====

### 15. PHYSICS

**Writer: Charles Zhang**

**Toss Up: Short Answer**

If an object attached to one end of a spring makes 20 complete oscillations in  $2\pi$  s, what is its angular frequency?

**Bonus Answer: 20 rad/s**

=====

**Bonus: Multiple Choice**

A 1-kg object attached to a spring whose spring constant is 400N/m executes simple harmonic motion. If its maximum speed is 5.0m/s, find the amplitude of its oscillation.

W) 0.1

X) 0.25 m

Y) 0.45

Z) 0.75

**Bonus Answer: X**

=====

### 16. BIOLOGY

**Writer: Janine Goh**

**Toss Up: Short Answer**

In which end of DNA is the hydroxyl group found?

**Bonus Answer: 3 prime**

---

**Bonus: Multiple Choice**

Which of the following are types of non-essential amino acids?

W) Phenylalanine and Valine

X) Leucine and Histidine

Y) Histidine and Lysine

Z) Arginine and Tyrosine

**Bonus Answer: Z**

=====

**17. 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**

=====

**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**

=====

**18. MATHEMATICS**

**Writer: Hanna Yang**

**Toss Up: Short Answer**

$(mn)^2 - p^2$

**Bonus Answer:  $(mn - p)(mn + p)$**

**Difference of Squares**

=====

**Bonus: Short Answer**

Factor  $a^4 + 4b^4$

**Bonus Answer:  $(a^2 + 2b^2 + 2ab)(a^2 + 2b^2 - 2ab)$**

**Solution:**

$a^4 + 4b^4 = a^4 + 4a^2b^2 + 4b^4 - 4a^2b^2$

$(a^2 + 2b^2)^2 - (2ab)^2 = (a^2 + 2b^2 + 2ab)(a^2 + 2b^2 - 2ab)$

**Difference of Squares**

**(This is also the Sophie Germain Identity)**

=====

**19. 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**

---

**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)**

---

## 20. BIOLOGY

**Writer: Janine Goh**

**Toss Up: Short Answer**

In DNA replication, the lagging strand is replicated in what fragments?

**Bonus Answer: Okazaki**

---

**Bonus: Short Answer**

Sickle-cell anemia is caused by what type of mutation?

**Bonus Answer: Point mutation/deletion**

---

## 21. 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)**

---

**Bonus: Multiple Choice**

The energy given off as heat by  $300\text{ g}$  of an alloy as it cools through  $50^{\circ}\text{C}$  (READ AS: 50 celsius degree) raises the temperature of  $300\text{ g}$  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**

---

## 22. CHEMISTRY

**Writer: Nicholas Adit**

**Toss Up: Multiple Choice**

Which of the following is closest in mass to a proton?

W) Alpha Particle

X) Positron

Y) Neutron

Z) Hydrogen Molecule

**Toss Up Answer: Y**

---

**Bonus: Short Answer**

What is the amount of calories of heat transferred to the water is when the temperature of a  $20\text{-gram}$  sample of water is increased from  $10^{\circ}\text{C}$  to  $30^{\circ}\text{C}$ ?

**Bonus Answer: 400**

---

## 23. PHYSICS

Writer: Raafiul Hossain

Toss Up: Short Answer

An educated guess or explanation for an observation or experimental result. Not yet fully accepted as fact is what?

Bonus Answer: Hypothesis

---

Bonus: Short Answer

A systematic methodology for gathering, organizing and applying knowledge is?

Bonus Answer: A scientific method

---

## 24. CHEMISTRY

Writer: Prangon Ghose

Toss Up: Multiple Choice

Which of the following elements has the largest number of possible oxidation states?

W) Fe

X) Cl

Y) Ca

Z) Mn

Toss Up Answer: X

---

Bonus: Multiple Choice

What is the minimum number of electrons needed to balance the following half-reaction with whole number coefficients?

$\text{IO}_3^- \rightarrow \text{I}_2$

W) 1 e<sup>-</sup>

X) 2 e<sup>-</sup>

Y) 5 e<sup>-</sup>

Z) 10 e<sup>-</sup>

Bonus Answer: Z

---

## 25. CHEMISTRY

Writer: Nicholas Adit

Toss Up: Short Answer

In 12.4 hours, a 100 gram sample of an element decays so that its mass is 25 grams. What is the approximate half-life of this radioactive substance?

Bonus Answer: 6.2 hours

---

Bonus: Multiple Choice

Which of the following will raise the boiling point of a sample of water?

W) Heat the water

X) Mix gasoline into the water

Y) Bring the water to a higher altitude

Z) Dissolve table sugar in the water

Bonus Answer: Z

---