

## Round 3

### 1. EARTH and SPACE

#### Toss Up: Short Answer

As of 2016, what is the innermost planet that has an orbital period longer than the average lifespan?

**Bonus Answer: Uranus**

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#### Bonus: Multiple Choice

What percentage of the total mass of the planets do Jupiter and Saturn make up?

W) 50

X) 75

Y) 90

Z) 95

**Bonus Answer: Y**

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### 2. MATHEMATICS

#### Toss Up: Multiple Choice

What is the geometric mean of the roots of the polynomial  $2x^3 - 2x^2 - 228x - 432$

W) 4

X) 6

Y) 8

Z) 10

**Toss Up Answer: X**

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#### Bonus: Short Answer

The first term of an arithmetic sequence is  $x$ , and the  $x$ th term is  $x^2$ , for  $x$  not equal to 1. If the common difference is equal to 7, what is the 12th term of the sequence?

**Bonus Answer: 84**

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### 3. ENERGY

#### Toss Up: Short Answer

What is the term for oil derived from oil shales or tar sands?

**Bonus Answer: Syncrude**

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#### Bonus: Multiple Choice

Burning of which of the following fuels produces the least amount of carbon dioxide per unit of energy?

W) coal

X) oil

Y) natural gas

Z) all of these produce the same amount of CO<sub>2</sub>

**Bonus Answer: Y**

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### 4. PHYSICS

#### Toss Up: Short Answer

A certain heat engine draws 500 cal/s from a water bath at 27° C and transfers 400 cal/s to a reservoir at a lower temperature. The efficiency of this engine is:

**Bonus Answer: 20%**

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#### Bonus: Multiple Choice

An Carnot refrigerator runs between a cold reservoir at temperature  $T_C$  and a hot reservoir at temperature  $T_H$ . You want to increase its coefficient of performance. Of the following, which change results in the greatest increase in the coefficient? The value of  $\Delta T$  is the same for all changes.

W) Raise the temperature of the hot reservoir by  $\Delta T$

X) Raise the temperature of the cold reservoir by  $\Delta T$

Y) Lower the temperature of the hot reservoir by  $1/2 \Delta T$  and raise the temperature of the cold reservoir by  $1/2 \Delta T$

Z) Lower the temperature of the cold reservoir by  $\Delta T$

**Bonus Answer: X**

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## 5. EARTH and SPACE

**Toss Up: Multiple Choice**

When a star undergoes helium flash, it fuses helium into which of the following elements?

W) Lithium

X) Beryllium

Y) Oxygen

Z) Carbon

**Toss Up Answer: Z**

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**Bonus: Short Answer**

Order the following 4 elements in most to least abundant in the solar system: 1. Carbon, 2. Hydrogen, 3. Oxygen, 4. Helium

**Bonus Answer: 2 (Hydrogen), 4(Helium), 3(Oxygen), 1(Carbon)**

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## 6. PHYSICS

**Toss Up: Multiple Choice**

Which of the following is NOT a state variable?

W) Work

X) Heat

Y) Entropy

Z) Pressure

**Toss Up Answer: W**

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**Bonus: Short Answer**

During an isobaric process, 80 joules of work is done on the surroundings by the gas. How much energy is added in joules?

**Bonus Answer: 200 joules**

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## 7. CHEMISTRY

**Toss Up: Multiple Choice**

Which of the following, when added to hydrofluoric acid, would decrease its acidity?

W) sodium fluoride

X) ammonium nitrate

Y) acetic acid

Z) sodium nitrate

**Toss Up Answer: W**

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**Bonus: Short Answer**

What is the name of the type of relatively unstable bonding found in many electron deficient compounds, such as  $\text{BeH}_2$ ?

Bonus Answer: three center bond

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## 8. EARTH and SPACE

### Toss Up: Multiple Choice

Which radioactive isotope is most useful for determining the age of mastodont bones found in late Pleistocene sediments?

- W) U-238
- X) C-14
- Y) K-40
- Z) Rb-87

Toss Up Answer: X

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### Bonus: Multiple Choice

The absolute age of a rock is the approximate number of years ago that the rock formed. The absolute age of an igneous rock can best be determined by

- W) comparing the amounts of decayed and undecayed radioactive isotopes in the rock
- X) comparing the sizes of the crystals found in the upper and lower parts of the rock
- Y) examining the rock's relative position in a rock outcrop
- Z) examining the environment in which the rock is found

Bonus Answer: W

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## 9. CHEMISTRY

### Toss Up: Multiple Choice

Which element has 10 stable isotopes, the highest of any element?

- W) Lead
- X) Xenon
- Y) Tin
- Z) Copper

Toss Up Answer: Y

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### Bonus: Short Answer

Name the compound that has a formula of C<sub>60</sub>.

Bonus Answer: buckminsterfullerene (or buckyballs)

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## 10. BIOLOGY

### Toss Up: Short Answer

What sequence on the mRNA of specific proteins determines whether or not the ribosome translating the mRNA will be bound to the rough endoplasmic reticulum?

Bonus Answer: Signal sequence (OR targeting signal, localization signal, localization sequence, transit peptide, or leader sequence)

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### Bonus: Short Answer

What are the three types of articulating vertebrae in the human vertebral column?

Bonus Answer: Cervical, thoracic, and lumbar vertebrae

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## 11. EARTH and SPACE

### Toss Up: Multiple Choice

Which of the following models of the Moon's origin is currently considered most likely?

- W) The Moon was spun off by a rapidly spinning, molten Earth.
- X) The Moon was a passing body that was captured by Earth's gravity.
- Y) The Moon formed in place at the same time that Earth formed.
- Z) The Moon was ejected from a molten Earth by a giant impact.

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

In which parts of Earth's interior would melted or partially melted material be found?

- W) stiffer mantle and inner core
- X) stiffer mantle and outer core
- Y) crust and inner core
- Z) asthenosphere and outer core

**Bonus Answer: Z**

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## 12. BIOLOGY

**Toss Up: Multiple Choice**

In living cells, chemical processes, such as synthesis, all require the action of

- W) specialized antibiotics
- X) hormones
- Y) salts
- Z) biological catalysts

**Toss Up Answer: Z**

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**Bonus: Short Answer**

The process of meiotic cell division in a human male usually forms what?

**Bonus Answer: Four monoploid cells**

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## 13. MATHEMATICS

**Toss Up: Short Answer**

What is  $(1000! + 999!)/(998!)$ ?

**Bonus Answer: 999,999**

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**Bonus: Short Answer**

What is the first number with 5 distinct prime factors?

**Bonus Answer: 2,310**

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## 14. BIOLOGY

**Toss Up: Multiple Choice**

The general term for a depression in a bone is

- W) fossa
- X) canal or meatus
- Y) facet
- Z) foramen

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

The suture that separates the parietal bones from the occipital bone is the...

- W) coronal suture
- X) lambdoid suture
- Y) sagittal suture.
- Z) squamous suture.

**Bonus Answer: X**

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## 15. PHYSICS

**Toss Up: Short Answer**

A gear with 40 teeth turns clockwise at 200 revolutions per minute. This gear is driving another gear with 20 teeth, which in turn is driving another gear with 80 teeth. How fast is the third gear going, and in what direction?

**Bonus Answer: 100 revolutions per minute clockwise**

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**Bonus: Multiple Choice**

A diverging lens produces an image of an object that is:

- W) virtual, smaller, and upright
- X) virtual, larger, and upright
- Y) real, smaller, and upside down
- Z) real, larger, and upright

**Bonus Answer: W**

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## 16. BIOLOGY

**Toss Up: Multiple Choice**

Which of these bones is part of the axial skeleton?

- W) rib
- X) clavicle
- Y) coxa
- Z) femur

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

A small, flattened articular surface is a

- W) facet
- X) fossa
- Y) tuberosity
- Z) ramus

**Bonus Answer: W**

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## 17. CHEMISTRY

**Toss Up: Short Answer**

In 1774, Joseph Priestly isolated what element by heating a powdered mercury compound?

**Bonus Answer: Oxygen**

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**Bonus: Multiple Choice**

Which of these is the strongest electrolyte

- W) HNO<sub>2</sub>

X)  $(\text{NH}_2)_2\text{CO}$

Y)  $\text{C}_2\text{H}_5\text{OH}$

Z)  $\text{NH}_4$

**Bonus Answer: W**

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## 18. PHYSICS

**Toss Up: Short Answer**

What is the name of the five points in a two body system where a small object can remain gravitationally stable?

**Bonus Answer: lagrange points**

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**Bonus: Multiple Choice**

Which of the following is the major contributor to an atom's mass?

W) the weak force

X) the strong force

Y) quarks

Z) the higgs boson

**Bonus Answer: X**

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## 19. MATHEMATICS

**Toss Up: Multiple Choice**

What mathematician proved the existence of a straight edge and compass construction of a regular 17-gon?

W) Euler

X) Euclid

Y) Gauss

Z) Galois [Gal-wah]

**Toss Up Answer: Y**

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**Bonus: Short Answer**

Given  $\sin X = 1/3$  [sine of x equals one third], compute  $\cos^2(3X)$  [co-sine squared of three x].

**Bonus Answer: -23/27**

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## 20. PHYSICS

**Toss Up: Multiple Choice**

Which is the weakest fundamental force?

W) The color force

X) The weak force

Y) Electromagnetism

Z) Gravity

**Toss Up Answer: Z**

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**Bonus: Short Answer**

Identify all of the following that are false:

1. Neutrinos travel at speed C
2. The strength of the color force can increase with distance
3. Electrons have color charge
4. All baryons are unstable

**Bonus Answer: 1, 3, 4**

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## 21. MATHEMATICS

### Toss Up: Multiple Choice

Which of the following is not a group?

W) the integers under multiplication

X) the integers under addition

Y) the symmetries of a regular n-gon

Z) the permutations of integers between 1 and n

**Toss Up Answer: W**

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### Bonus: Short Answer

find the smallest positive solution to the following congruences.

x congruent to 3 mod 13

x congruent to 8 mod 11

**Bonus Answer: x=107**

**Also accept: 107**

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## 22. CHEMISTRY

### Toss Up: Short Answer

Which famous chemist was responsible for creating the field of colloid chemistry and created laws for effusion and diffusion

**Bonus Answer: Thomas Graham**

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### Bonus: Short Answer

What law, proposed by Joseph Proust, states that a chemical compound will always have its own characteristic ratio of elemental components?

**Bonus Answer: The Law of Definite Proportions (Law of constant composition)**

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## 23. CHEMISTRY

### Toss Up: Multiple Choice

The change in entropy is zero for:

W) reversible adiabatic processes

X) reversible isothermal processes

Y) reversible processes during which no work is done

Z) . all adiabatic processes

**Toss Up Answer: W**

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### Bonus: Multiple Choice

The Hall-Heroult process is used in the production of:

W) Mg

X) Fe

Y) Al

Z) Au

**Bonus Answer: Y**

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## 24. CHEMISTRY

### Toss Up: Short Answer

Which famous chemist formulated the rule that mass is conserved through chemical reactions?

**Bonus Answer: Lavoisier**

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**Bonus: Multiple Choice**

Which of the following is the strongest oxidizing agent?

W)  $\text{Pb}^{2+}$

X)  $\text{I}_2$

Y)  $\text{Ag}^+$

Z) Pb

**Bonus Answer: Y**

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**25. CHEMISTRY**

**Toss Up: Multiple Choice**

What is the hybridization of the sulfur atom in  $\text{SF}_4$ ?

W)  $\text{sp}^2$

X)  $\text{sp}^3$

Y)  $\text{sp}^3\text{d}$

Z)  $\text{sp}^3\text{d}^2$

**Toss Up Answer: Y**

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**Bonus: Short Answer**

Which famous chemist proposed the modern kinetic molecule theory for gasses?

**Bonus Answer: Bernoulli**

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