Round 3

1. PHYSICS

Writer: Charles Zhang

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%

Bonus: Multiple Choice

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

W) Raise the temperature of the hot reservoir by ΔT

X) Raise the temperature of the cold reservoir by ΔT

Y) Lower the temperature of the hot reservoir by 1 2 ΔT and raise the temperature of the cold reservoir by 1 2 ΔT

Z) Lower the temperature of the cold reservoir by ΔT

Bonus Answer: X

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2. PHYSICS

Writer: Charles Zhang

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

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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3. PHYSICS

Writer: Andrew Chen

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

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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4. PHYSICS

Writer: Andrew Chen

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

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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5. PHYSICS

Writer: Wilson Berkow

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

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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6. MATHEMATICS

Writer: Seiji Yawata

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

Bonus: Short Answer

The first term of an arithmetic sequence is x, and the xth 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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7. MATHEMATICS

Writer: Shamaul Dilmohamed

Toss Up: Short Answer

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

Bonus Answer: 999,999

Bonus: Short Answer

What is the first number with 5 distinct prime factors?

Bonus Answer: 2,310

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8. MATHEMATICS

Writer: Steven Litvack-Winkler

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

Bonus: Short Answer

Given sinX=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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9. MATHEMATICS

Writer: Steven Litvack-Winkler

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

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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10. BIOLOGY

Writer: Joyce Lei

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)

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. BIOLOGY

Writer: Aaron Gee

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

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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12. BIOLOGY

Writer: Amrit Hingorani

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

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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13. BIOLOGY

Writer: Amrit Hingorani

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

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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14. CHEMISTRY

Writer: Andrew Chen

Toss Up: Multiple Choice

Which noble gas is the most reactive?
W) Xenon
X) Radon
Y) Helium
Z) Argon

Toss Up Answer: W

Bonus: Short Answer

How many carbon atoms are in a single molecule of trinitrotolulene, or TNT?

Bonus Answer: 7

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15. CHEMISTRY

Writer: Andrew Chen

Toss Up: Short Answer

Which nitrogen hydride is the most stable?

Bonus Answer: ammonia

Bonus: Multiple Choice

Why isn't silicon a suitable candidate for life like carbon is?
W) Silicon is too heavy
X) Silicon atoms are too big to form pi bonds
Y) Silicon is more reactive
Z) Silicon is rarer in the earth's crust

Bonus Answer: X

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16. CHEMISTRY

Writer: Andrew Chen

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

Bonus: Short Answer

What is the name of the type of relatively unstable bonding found in many electron deficient compounds, such as BeH_2?

Bonus Answer: three center bond

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17. CHEMISTRY

Writer: Andrew Chen

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

Bonus: Short Answer

Name the compound that has a formula of C60.

Bonus Answer: buckminsterfullerene (or buckyballs)

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18. CHEMISTRY

Writer: Nicholas Parker Ng

Toss Up: Short Answer

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

Bonus Answer: Oxygen

Bonus: Multiple Choice

Which of these is the strongest electrolyte

W) HNO2

X) (NH2)2CO

Y) C2H5OH

Z) NH4

Bonus Answer: W

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19. CHEMISTRY

Writer: Nicholas Parker Ng

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

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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20. EARTH and SPACE

Writer: Nicholas Parker Ng

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

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) omparing 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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21. EARTH and SPACE

Writer: William Chan

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

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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22. EARTH and SPACE

Writer: William Chan

Toss Up: Multiple Choice

Within the early Earth's vast molten region, substances underwent a process known as differentiation, during which

W) substanes of low density rise to Earth's surface, while those of high density sink toward its center

X) substances of high density float to Earth's surface, while those of low density sink toward its center.

Y) substances of high and low density chemically combine to form uniformly dense substances.

Z) substances of high density form gases, while those of low density form solids.

Toss Up Answer: W

Bonus: Multiple Choice

Earth's magnetic field is likely a result of

W) convection currents in Earth's mantle

X) convection currents in Earth's core

Y) a high concentration of iron in Earth's crust

Z) high-energy particles in the solar wind

Bonus Answer: X

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23. EARTH and SPACE

Writer: William Chan

Toss Up: Multiple Choice

Which statement best describes how galaxies generally move?

W) Galaxies move toward one another.

X) Galaxies move away from one another.

Y) Galaxies move randomly.

Z) Galaxies do not move.

Toss Up Answer: X

Bonus: Multiple Choice

The observable universe is estimated to be roughly 16-20 billion years old. Which statement best describes why a galaxy located 25 billion light-years from Earth may not be visible to an observer on Earth?

W) Galaxies 25 billion light-years away would emit no visible light.

X) Light from beyond 20 billion light years has not yet reached Earth.

Y) Light from beyond 20 billion light years passed out galaxy before Earth existed.

Z) No galaxies are located farther than 5 billion light-years from Earth.

Bonus Answer: X

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24. EARTH and SPACE

Writer: William Chan

Toss Up: Multiple Choice

Rock samples brought back from the Moon show absolutely no evidence of chemical weathering. This is most likely due to

W) the lack of an atmosphere on the Moon

X) extremely low surface temperatures on the Moon

Y) lack of biological activity on the Moon

Z) large quantities of water in the lunar "seas"

Toss Up Answer: W

Bonus: Multiple Choice

A major belt of asteroids is located between Mars and Jupiter. What is the approximate average distance between the Sun and this major asteroid belt?

W) 110 million kilometers

X) 220 million kilometers

Y) 390 million kilometers

Z) 850 million kilometers

Bonus Answer: Y

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25. ENERGY

Writer: Nicholas Parker Ng

Toss Up: Short Answer

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

Bonus Answer: Syncrude

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_2

Bonus Answer: Y

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