

Round 6

1. MATHEMATICS

Toss Up: Short Answer

Tim is 5 times older than his younger brother. In 3 years Tim will be 3 times older than his younger brother. Compute the difference in the ages of Tim and his younger brother.

Bonus Answer: 12

Bonus: Short Answer

How many positive integers n have no solutions to the following equation where a and b are nonnegative integers?

$$3a + 7b = n$$

Bonus Answer: 6

2. CHEMISTRY

Toss Up: Short Answer

How many nodes does a 3p orbital have?

Bonus Answer: 2

Bonus: Short Answer

Name any amino acid that contains a phenyl group.

Bonus Answer: Phenylalanine, Tyrosine, Tryptophan

3. 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

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

4. CHEMISTRY

Toss Up: Multiple Choice

Which element has the lowest atomic number with no stable isotopes?

W) Bismuth

X) Technetium

Y) Uranium

Z) Radium

Toss Up Answer: X

Bonus: Short Answer

What color is the H-alpha spectral line?

Bonus Answer: Red

5. ENERGY

Toss Up: Multiple Choice

What is one advantage to geothermal energy?

W) Low cost

X) Can be built anywhere

Y) Doesn't produce any hazardous chemicals

Z) Will never run out of steam

Toss Up Answer: W

Bonus: Short Answer

In an internal combustion engine, what is the name of the device that ignites the fuel?

Bonus Answer: Spark plug

6. BIOLOGY

Toss Up: Multiple Choice

Oogenesis in humans begins

W) during embryonic development

X) at birth

Y) at puberty

Z) monthly during the menstrual cycle

Toss Up Answer: W

Bonus: Multiple Choice

In birds and mammals, gastrulation begins at the

W) trophoblast

X) blastodisc

Y) blastocyst

Z) primitive streak

Bonus Answer: Z

7. EARTH and SPACE

Toss Up: Short Answer

What body is the most volcanic in the solar system?

Bonus Answer: Io

Bonus: Short Answer

What effect gives Io the energy for this volcanic activity?

Bonus Answer: Tidal heating (accept: tidal friction, tidal forces, tidal forces by Jupiter, tidal forces by Jupiter and its moons)

8. EARTH and SPACE

Toss Up: Short Answer

From what body do astronomers believe most comets originate?

Bonus Answer: The Oort Cloud

Bonus: Short Answer

Which tail of a comet is always directed in the opposite direction of the Sun?

Bonus Answer: The ion tail (accept: gas tail. Reject dust tail as incorrect.)

9. 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

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

10. MATHEMATICS

Toss Up: Multiple Choice

MULTIPLE CHOICE: tossup

For an infinite sequence of numbers a_0, a_1, \dots , which of the following best describes the polynomial $P(x) = \sum_{i=0}^{\infty} a_i x^i$.

W) Reimann-Zeta function

X) Generating function

Y) Newtonian series

Z) Tchebychev polynomial

Toss Up Answer: X

Bonus: Short Answer

In the Pell equation $x^2 - 3y^2 = 1$ the smallest solution is $x=2$ and $y=1$. The next smallest solution is $x=7$ and $y=4$. Compute the third smallest solution.

Bonus Answer: x=26, y=15

Also accept (26,15)

11. PHYSICS

Toss Up: Multiple Choice

A closed hemispherical shell of radius R is filled with fluid at uniform pressure p. The net force of the fluid on the curved portion of the shell is given by:

W) $2\pi R^2 p$ (read as 2 pi times R squared times p)

X) $4\pi R^2 p$ (read as 4 pi times R squared times p)

Y) $\pi R^2 p$ (read as pi times R squared times p)

Z) $(4/3)\pi R^2 p$ (read as 4 over 3 times pi times R squared times p)

Toss Up Answer: Y

Bonus: Short Answer

A boat floating in fresh water displaces 16,000N of water. How many newtons of saltwater would it displace if it floats in saltwater of specific gravity 1.17?

Bonus Answer: 16,000

12. CHEMISTRY

Toss Up: Short Answer

Which form of coal has the highest percentage of carbon?

Bonus Answer: anthracite

Bonus: Multiple Choice

Which of the following is a salt?

- W) Water
- X) Soap
- Y) Plastic
- Z) Rust

Bonus Answer: X

13. PHYSICS

Toss Up: Short Answer

Given G as the gravitational constant and there exists an equilateral triangle with side length " a " and identical objects with mass of " x " what is the total gravitational potential energy of an object with mass " y " that is located at the center?

Bonus Answer: $-G(xy) \frac{3\sqrt{3}}{a}$

Bonus: Multiple Choice

Given G as the gravitational constant and there exists an equilateral triangle with side length " a " and identical objects with mass of " x " what is the total gravitational potential energy of this system?

- W) $-9\sqrt{3}G(xy)/a$ (read as negative nine times square root of 3 times G times the second power of x divided by a)
- X) $-3\sqrt{3}G(x^2)/a$ (read as negative three times square root of 3 times G times the second power of x divided by a)
- Y) $-3G(x^2)/a$ (read as negative three times G times the second power of x divided by a)
- Z) $-\sqrt{3}G(x^2)/a$ (read as negative square root of 3 times G times the second power of x divided by a)

Bonus Answer: Y

14. CHEMISTRY

Toss Up: Multiple Choice

Which type of nuclear reactor does not require a moderator?

- W) Light Water Reactor
- X) Heavy Water Reactor
- Y) Graphite Moderated Reactor
- Z) Fast Breeder Reactor

Toss Up Answer: Z

Bonus: Short Answer

Which types of fuel cells mainly use platinum catalysts?

- PEMFC
- PAFC
- DMFC
- MCFC

Bonus Answer: 1 and 3

15. PHYSICS

Toss Up: Multiple Choice

What's the critical angle in radians when a ray passes from a medium with index of refraction of 1.4 to a medium with index of refraction of 0.7?

W) $\pi/2$

X) $\pi/3$

Y) $\pi/6$

Z) π

Toss Up Answer: Y

Bonus: Short Answer

A concave spherical mirror has a focal length of 12 cm. If an object is placed 6 cm in front of it the image position is:

Bonus Answer: 12cm behind the mirror (accept -12cm)

16. CHEMISTRY

Toss Up: Multiple Choice

Although water molecules are locked together by strong hydrogen bonds, they can reconfigure themselves through which phenomena:

W) Adhesion

X) Brownian Motion

Y) Quantum Tunneling

Z) The Mpemba Effect

Toss Up Answer: Y

Bonus: Short Answer

Superfluidity is a state of matter which exhibits which of the following properties:

Extreme surface tension

Near-zero viscosity

High electrical conductivity

High thermal conductivity

Bonus Answer: 2 and 4

17. BIOLOGY

Toss Up: Multiple Choice

Which of the following is an example of an excretory mechanism?

W) Antibodies

X) Flame cells

Y) Neurosecretory cells

Z) The sarcomere

Toss Up Answer: X

Bonus: Multiple Choice

Body temperature can be increased by all of the following EXCEPT:

W) muscle contractions

X) drinking alcohol, which results in vasodilation

Y) puffing up feathers or hair

Z) reducing blood flow to ears

Bonus Answer: X

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18. EARTH and SPACE

Toss Up: Short Answer

Which planet in the solar system has the greatest albedo?

Bonus Answer: Venus

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Bonus: Multiple Choice

What gas is most abundant in the troposphere of Venus?

W) Carbon dioxide

X) Nitrogen

Y) Sulfur dioxide

Z) Methane

Bonus Answer: W

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19. EARTH and SPACE

Toss Up: Short Answer

Order the following structures by descending concentration of stars:

1. Globular cluster

2. Arms of the Milky Way

3. Bulge of the Milky Way

4. Halo of the Milky Way

Bonus Answer: 1, 3, 2, 4

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Bonus: Short Answer

What stellar Population is most common in globular clusters?

Bonus Answer: Population II (accept "2")

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20. PHYSICS

Toss Up: Short Answer

The Kondo effect describes this quantity's divergence at low temperatures. Strain gauges operate by detecting changes in this quantity, because it is proportional to length and inversely proportional to cross-sectional area. Its AC-circuit extension is the complex quantity impedance, and its inverse, measured in siemens, is the conductance. Equal to voltage divided by current, according to Ohm's law, it is high for insulators and low for conductors. Name this measure of how much an object opposes electric current.

Bonus Answer: Resistance

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Bonus: Short Answer

What's the emf in volts produced by an inductor with an inductance of 0.3 henry and a current with equation $I(t) = 2t^2 + 2$ after 3 seconds of operation?

Bonus Answer: 3.6 volts

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21. CHEMISTRY

Toss Up: Multiple Choice

Vacuum systems require materials with very low outgassing rates. Which of these metals would be suitable for use in a vacuum chamber?

W) Cadmium

X) Zinc

Y) Magnesium

Z) Aluminum

Toss Up Answer: Z

Bonus: Multiple Choice

Which one of these crystal lattice structures best describes the networking of Ti, Zn, and Mg?

- W) BCC
- X) FCC
- Y) HCP
- Z) LFC

Bonus Answer: Y

22. EARTH and SPACE

Toss Up: Multiple Choice

What is defined to be the distance from the Sun, to a body whose stellar parallax is one arcsecond?

- W) astronomical unit
- X) Schwarzschild radius
- Y) parsec
- Z) light-second

Toss Up Answer: Y

Bonus: Multiple Choice

An amateur astronomer observes a star over the course of a year and finds that from January 1 to June 1, the star's position on the celestial sphere shifts by 3 arcseconds. How far is the star from the Earth, to the nearest tenth of a parsec?

- W) 3
- X) 0.3
- Y) 1.5
- Z) 0.7

Bonus Answer: Z

23. BIOLOGY

Toss Up: Multiple Choice

All of the following are found in both roots and stems EXCEPT:

- W) Casparian strip
- X) primary phloem
- Y) primary xylem
- Z) secondary xylem

Toss Up Answer: W

Bonus: Multiple Choice

All of the following occur in a phototropic response EXCEPT:

- W) Shoots bend toward light
- X) Auxin is produced at the shoot tip and diffuses down the stem
- Y) Auxin accumulates on the shady side of the shoot
- Z) Auxin transport is unidirectional

Bonus Answer: X

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24. BIOLOGY

Toss Up: Multiple Choice

In plants, male gametes are produced by the

- W) ovary
- X) pistil
- Y) antheridium
- Z) archegonium

Toss Up Answer: Y

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Bonus: Multiple Choice

The deuterostomes differ from protostomes in all of the following respects EXCEPT:

- W) early cleavage of the zygote
- X) ultimate function of the opening to the archenteron
- Y) number of germ layers in the developing embryo
- Z) embryonic origin of the mouth

Bonus Answer: Y

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25. BIOLOGY

Toss Up: Multiple Choice

All of the following are examples of substances found in bacteria or archaea EXCEPT:

- W) peptidoglycan
- X) flagellin
- Y) chitin
- Z) phycobilin

Toss Up Answer: Y

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Bonus: Multiple Choice

Which of the following groups of organisms lacks motility?

- W) Cellular slime molds
- X) Ciliates
- Y) Dinoflagellates
- Z) Apicomplexans

Bonus Answer: Z

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