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## 1. Mathematics

### Toss Up: Multiple Choice

Which of the following are prime factors of the number 5304?

W) 19

X) 7

Y) 5

Z) 13

Toss Up Answer: Z

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### Bonus: Short Answer

What integer satisfies the equation  $y = x^3 - 1$  [Read as: x to the third power subtracted by 1] when  $y = 0$  ?

Bonus Answer:  $x = 1$

(Explanation: The factors of the equation is  $y = (x - 1)(x^2 + x + 1)$ . We want to find an integer solution, so we take the factor  $x - 1$  and set it to zero. By adding one to both sides, we see that  $x = 1$ .)

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## 2. Earth and Space Science

### Toss Up: Short Answer

As it pertains to, say, a recent rain storm, what zone would lie right above the impermeable bedrock?

Toss Up Answer: zone of saturation

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### Bonus: Short Answer

In the zone of aeration, groundwater is present between spaces and cracks in soil and rock grains. What is this groundwater known as?

Bonus Answer: capillary water

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## 3. Biology

### Toss Up: Multiple Choice

Which of the following tissues is MOST directly responsible for the increased diameter of a tree trunk from year to year?

W) apical meristem

X) pericycle

Y) vascular cambium

Z) pith

Toss Up Answer: Y

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### Bonus: Short Answer

Name all of the following 3 metabolic processes which directly require oxygen: glycolysis; alcohol fermentation; electron transport system

Bonus Answer: Electron transport system

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## 4. Chemistry

### Toss Up: Multiple Choice

Identify the INCORRECT statement below:

W) In the most fundamental sense, the properties of the elements are periodic functions of their atomic weight.

- X) The vertical columns of the periodic chart are called groups, sharing similar properties.  
Y) Elements with atomic numbers of 9, 17, 35, and 53 are members of the halogen family, meaning "salt formers."  
Z) Elements Li, B, N and F are all in the same period.

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

All of the following statements are true EXCEPT:

- W) the enthalpy change of an endothermic reaction is positive.  
X) at constant pressure the heat flow for a reaction equals the change in enthalpy.  
Y)  $\Delta H$  for a reaction is equal in magnitude but opposite in sign to  $\Delta H$  for the reverse reaction.  
Z) enthalpy change is dependent upon the number of steps in a reaction.

**Bonus Answer: Z**

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## 5. Physics

**Toss Up: Multiple Choice**

Who first suggested that radiant energy could exist only in discrete quanta which were proportional to the frequency in order to explain the frequency distribution of blackbody radiation?

- W) Isaac Newton  
X) Max Planck  
Y) Ernest Rutherford  
Z) Paul Dirac

**Toss Up Answer: X**

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**Bonus: Short Answer**

Later solved by Planck's quantum radiation formula, what asymptotic result of the classical Rayleigh-Jeans Law was the most troubling?

**Bonus Answer: Ultraviolet Catastrophe**

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## 6. Mathematics

**Toss Up: Multiple Choice**

What do the numbers in the  $n$ th row of Pascal's Triangle sum to?

Give your answer in terms of  $n$ .

- W)  $2n$   
X)  $2^n$   
Y)  $n^2$   
Z)  $n^3$

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

Find the number of ordered pairs  $(a,b)$ , where  $a$  and  $b$  are nonnegative integers, such that  $a+b=10$ .

- W) 100  
X) 10  
Y) 11

Z) 12

Bonus Answer: Y

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## 7. Earth and Space Science

Toss Up: Short Answer

In which direction are winds and ocean currents deflected in the Southern Hemisphere?

Toss Up Answer: left

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Bonus: Multiple Choice

Which of the following does not support the heliocentric model?

W) Coriolis effect

X) rotation of the Foucault pendulum

Y) epicycles

Z) direct motion

Bonus Answer: Y

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## 8. Energy

Toss Up: Short Answer

Cadmium and boron are used in a nuclear reactor to absorb which subatomic particle?

Toss Up Answer: Neutron

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Bonus: Short Answer

The electrical resistance of a semiconducting wire is least likely to be reduced by a decrease in which of the following four wire characteristics?

Radius, Melting Point, Length, or Temperature?

Bonus Answer: Melting Point

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## 9. Mathematics

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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## 10. Earth and Space Science

Toss Up: Multiple Choice

Which of the following is an extrusive igneous rock?

W) Granite

- X) Obsidian
- Y) Slate
- Z) Diorite

Toss Up Answer: X

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**Bonus: Multiple Choice**

Which of the following minerals is the hardest?

- W) Quartz
- X) Talc
- Y) Feldspar
- Z) Corundum

Bonus Answer: Z

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## 11. Mathematics

**Toss Up: Multiple Choice**

What are the solutions for x in the following equation:  $x^2 - 2x = 8$ ?

- W) 0
- X) 0 and -2
- Y) 4 and -2
- Z) -4 and 2

Toss Up Answer: Y

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**Bonus: Multiple Choice**

The sum of the squares of reciprocals of all positive integers equals which of the following?

- W)  $\pi^{1/2}$  (read as square root of pi)
- X)  $\pi/3$
- Y)  $\pi^2/6$
- Z)  $\pi^3/12$

Bonus Answer: Y

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## 12. Earth and Space Science

**Toss Up: Multiple Choice**

Which of the following is not a typical storm track in the United States?

- W) from Alberta straight to Maine
- X) from the Gulf states northward along the eastern seaboard
- Y) from Colorado to the Appalachian Mountains
- Z) from the Pacific Northwest to the Southeastern US by way of Texas

Toss Up Answer: Z

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**Bonus: Multiple Choice**

Present day weather predictions are based primarily upon

- W) land and sea breezes

- X) cloud height
- Y) air mass movements
- Z) ocean currents

Bonus Answer: Y

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### 13. Physics

#### Toss Up: Multiple Choice

An electron is placed in a horizontally hollow cylindrical solenoid with the current moving clockwise around the solenoid. The electron is released from rest in the middle of the solenoid. What direction will the electron move in?

- W) To the left
- X) To the right
- Y) Stays in the same place
- Z) Oscillates between both ends

Toss Up Answer: X

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#### Bonus: Multiple Choice

There are two charges, one with charge  $+2Q$  and one with charge  $-4Q$  a distance of 2 meters from each other. Assuming the universal charge constant is  $1.6 \times 10^{-19}$ , which of the following is the force of attraction felt by the two charges, rounded to one decimal place

- W)  $4.8 \times 10^{-19}$  C
- X)  $9.6 \times 10^{-19}$  C
- Y)  $2.4 \times 10^{-19}$  C
- Z)  $3.2 \times 10^{-19}$  C

Bonus Answer: Z

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### 14. Biology

#### Toss Up: Multiple Choice

Birds are able to sustain long flights at high altitudes because they

- W) can extract oxygen during both inhalation and exhalation
- X) use anaerobic metabolism during flight
- Y) are able to lower their body temperature during flight
- Z) decrease their heart rate during flight

Toss Up Answer: W

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#### Bonus: Multiple Choice

Carbon monoxide (CO) is toxic to humans because

- W) it binds to myoglobin and causes it to denature.
- X) it is rapidly converted to toxic CO<sub>2</sub>.
- Y) it binds to the globin portion of hemoglobin and prevents the binding of O<sub>2</sub>.
- Z) it binds to the Fe in hemoglobin and prevents the binding of O<sub>2</sub>.

Bonus Answer: Z

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## 15. Chemistry

### Toss Up: Short Answer

Each element has its own electron configuration. What is the electron configuration of chromium (Cr).

Toss Up Answer: [Ar] 3d<sup>5</sup> 4s<sup>1</sup> (Also accept 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>6</sup> 3d<sup>5</sup> 4s<sup>1</sup>)

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### Bonus: Multiple Choice

There are various numbers of pi and sigma bonds in certain compounds. Which of the choices below best describes the number of pi and sigma bonds ethyne (acetylene) has?

W) 1 pi bonds and 4 sigma bonds

X) 3 pi bonds and 2 sigma bonds

Y) 2 pi bonds and 3 sigma bonds

Z) 4 pi bonds

Bonus Answer: Y

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## 16. Mathematics

### Toss Up: Multiple Choice

For which of the following values of x is  $(x^2+x+4)/(x)$  an integer?

W) 3

X) 4

Y) 5

Z) 6

Toss Up Answer: X

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### Bonus: Short Answer

Find the remainder when  $343x^3+49x^2+14x+1$  is divided by  $7x - 1$ .

Bonus Answer: 5

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## 17. Chemistry

### Toss Up: Short Answer

Mixing 250 mL of 2.0 M sulfuric acid with 2 liters of 0.5 M sodium hydroxide will produce a solution with what pH?

Toss Up Answer: 7

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### Bonus: Short Answer

Which of the following are strong bases: lithium hydroxide, strontium hydroxide, cesium hydroxide, barium hydroxide?

Bonus Answer: All except cesium hydroxide

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## 18. Physics

### Toss Up: Multiple Choice

Block A, with a mass of 4 kg, is moving with a speed of 3.0m/s while block B, with a mass of 8 kg, is moving in the opposite direction with a speed of 3.0m/s. The center of mass of the two block-system is moving with a velocity of:

W) 1.0 m/s in the same direction as B

X) 1.3 m/s in the same direction as A

Y) 4.0 m/s in the same direction as B

Z) 6.0 m/s in the same direction as A

Toss Up Answer: W

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**Bonus: Multiple Choice**

A 60kg hunter gets a rope around a 300kg polar bear. They are stationary, 12m apart, on frictionless level ice. When the hunter pulls the polar bear to him, the polar bear will move:

W) 0.5 m

X) 2 m

Y) 4 m

Z) 7m

Bonus Answer: X

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## 19. Chemistry

**Toss Up: Multiple Choice**

The Standard Gibb's free energy,  $\Delta G^\circ$ , is

W) the residual energy present in the reactants at equilibrium

X) the residual energy present in the products at equilibrium

Y) the energy required to convert one mole of reactants to one mole of products

Z) the difference in the residual energy of reactants and products at equilibrium

Toss Up Answer: X

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**Bonus: Multiple Choice**

If the enthalpy change for a reaction is zero,  $\Delta G^\circ$  is equal to

W)  $T\Delta S^\circ$

X)  $-T\Delta S^\circ$

Y)  $-\Delta H^\circ$

Z)  $\ln K_{eq}$

Bonus Answer: X

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## 20. Earth and Space Science

**Toss Up: Short Answer**

By name or number, which of the following is not a mineral: diamond, gold, coal, silt

Toss Up Answer: Coal and silt (accept 3 and 4)

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**Bonus: Short Answer**

The Mohs scale is used to measure mineral hardness. By name or number order the following minerals in increasing order: Fluorite, Gypsum, Quartz, Talc

Bonus Answer: Talc, Gypsum, Fluorite, Quartz (accept 1 2 3 4, in that order)

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## 21. Biology

**Toss Up: Multiple Choice**

What enzyme in the digestive system first breaks down starches?

W) protease

- X) secretin
- Y) cholecystokinin
- Z) amylase

**Toss Up Answer: Z**

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**Bonus: Short Answer**

What cavity is used cnidarians in digestion?

**Bonus Answer: gastrovascular cavity**

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## 22. Chemistry

**Toss Up: Multiple Choice**

Which of the following has a coordinate covalent bond?

- W) butanol
- X) CO<sub>2</sub>
- Y) Methane
- Z) NH<sub>4</sub><sup>+</sup>

**Toss Up Answer: Z**

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**Bonus: Short Answer**

What is the formal charge of Nitrogen in an ammonia molecule?

**Bonus Answer: 0**

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## 23. Biology

**Toss Up: Short Answer**

Name all of the following genetic disorders that exhibit dominant inheritance.

1. achondroplasia
2. polydactyly
3. cri-du-chat syndrome
4. Huntington's disease

**Toss Up Answer: 1, 2, 4**

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**Bonus: Short Answer**

Name all of the following genetic disorders that result from chromosomal abnormalities.

1. Down syndrome
2. color blindness
3. cri-du-chat
4. Klinefelter's Syndrome

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

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## 24. Physics

**Toss Up: Short Answer**

An electron is being held in an electric field. The direction of the electric field lines of the electric field are East. In what direction will the electron move when it is released.

**Toss Up Answer: West (accept: Left)**

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**Bonus: Multiple Choice**



A proton is traveling to the right with a velocity of 1m/s and there is a magnetic field of 3 Teslas coming towards you. What is the direction and magnitude of the force, in scientific notation to the nearest tenth, felt by the proton?

W)  $4.8 \times 10^{-19}$  N down

X)  $4.8 \times 10^{-19}$  N up

Y)  $3.6 \times 10^{-19}$  N down

Z)  $3.6 \times 10^{-19}$  N up

**Bonus Answer: W**

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## 25. Physics

**Toss Up: Short Answer**

A train moving 35 meters per second emits a whistle with a frequency of 900 hertz. Assuming that the speed of sound in air is 350 meters per second, what is the frequency, in hertz, measured by a stationary observer in front of the train?

**Toss Up Answer: 1000**

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**Bonus: Multiple Choice**

Which of the following has the highest vapor pressure at STP?

W) mercury

X) ethyl alcohol

Y) methyl alcohol

Z) acetone

**Bonus Answer: Z**

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