

## ROUND 2

### TOSS-UP

1) Energy – *Short Answer* Identify all the following three categories of fuel cells that can be considered types of proton exchange membrane fuel cells? 1) Direct-methanol, 2) Molten carbonate, 3) Phosphoric acid.

ANSWER: 1 AND 3

### BONUS

1) Energy – *Multiple Choice* Which of the following molecules is used as a standard for determining the octane rating of gasoline?

- W) 2,2,4-trimethylpentane [*try-methyl-PEN-tane*]
- X) N-octane
- Y) 3-methylheptane [*methyl-HEP-tane*]
- Z) 2,2,3,3-tetramethylbutane [*tetra-methyl-BYOO-tane*]

ANSWER: W) 2,2,4-TRIMETHYLPENTANE

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### TOSS-UP

2) Earth and Space – *Multiple Choice* What gas accounts for approximately 78% of the dry volume of Earth's atmosphere?

- W) Oxygen
- X) Nitrogen
- Y) Argon
- Z) Carbon dioxide

ANSWER: X) NITROGEN

### BONUS

2) Earth and Space – *Short Answer* COROT [*KOH-roh*] was a mission run by the European Space Agency to find what type of celestial objects?

ANSWER: EXOPLANETS (ACCEPT: EXTRASOLAR PLANETS, PLANETS)

**TOSS-UP**

3) Physics – *Short Answer* What principle states that the net response at a given point caused by two waves is the sum of the responses that those waves would have caused individually?

ANSWER: SUPERPOSITION

**BONUS**

3) Physics – *Short Answer* What is the term for the useful work that can be obtainable from a closed system at constant temperature?

ANSWER: HELMHOLTZ FREE ENERGY

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**TOSS-UP**

4) Biology – *Multiple Choice* The citric acid cycle is a component of what kind of metabolic process?

- W) Aerobic respiration
- X) Anaerobic respiration
- Y) Fermentation
- Z) Photosynthesis

ANSWER: W) AEROBIC RESPIRATION

**BONUS**

4) Biology – *Multiple Choice* Which of the following best describes a lysogenic cell?

- W) It contains a prophage
- X) It is immune to viral infection
- Y) It is actively producing viral particles
- Z) It is about to lyse

ANSWER: W) IT CONTAINS A PROPHAGE

**TOSS-UP**

5) Chemistry – *Multiple Choice* In dilute aqueous solution,  $\text{H}_2\text{SO}_4$  is classified as which of the following?

- W) Strong acid
- X) Weak acid
- Y) Strong base
- Z) Weak base

ANSWER: W) STRONG ACID

**BONUS**

5) Chemistry – *Multiple Choice* What signs for enthalpy and entropy changes, respectively, guarantee a spontaneous reaction at all temperatures?

- W) Positive, positive
- X) Positive, negative
- Y) Negative, positive
- Z) Negative, negative

ANSWER: Y) NEGATIVE, POSITIVE

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**TOSS-UP**

6) Math – *Short Answer* What is the second derivative with respect to  $x$  of  $2x^3 - 12$  evaluated at  $x = 3$ ?

ANSWER: 36

**BONUS**

6) Math – *Short Answer* Solve the following equation for  $y$ :  $3y$  minus open parenthesis 2 minus  $2y$  close parenthesis plus 5 = 15 minus  $y$ .

ANSWER: 2

**TOSS-UP**

7) Energy – *Short Answer* What is the primary gaseous element of wood gas, a product of gasification?

ANSWER: NITROGEN

**BONUS**

7) Energy – *Multiple Choice* Which of the following user facilities at the Department of Energy would be best utilized to determine the building blocks of matter created just after the Big Bang?

- W) Advanced Photon Source
- X) Relativistic Heavy Ion Collider
- Y) High Flux Isotope Reactor
- Z) Synchrotron Radiation Lightsource

ANSWER: X) RELATIVISTIC HEAVY ION COLLIDER



**TOSS-UP**

8) Biology – *Multiple Choice* Which of the following processes is used to produce additional ATP for the light-independent reactions of photosynthesis?

- W) Cyclic electron flow
- X) Lactic acid fermentation
- Y) Glycolysis [*glye-KAWL-eh-sis*]
- Z) Beta oxidation

ANSWER: W) CYCLIC ELECTRON FLOW

**BONUS**

8) Biology – *Short Answer* Place the following four structures in order from inside to outside for stems with a vascular cylinder: 1) Pericycle; 2) Cortex; 3) Epidermis; 4) Pith.

ANSWER: 4, 1, 2, 3

**TOSS-UP**

9) Physics – *Short Answer* For an airplane in steady, level flight, what resisting force is equal and opposite to the vehicle thrust?

ANSWER: DRAG (ACCEPT: AIR RESISTANCE, FRICTION)

**BONUS**

9) Physics – *Short Answer* To the nearest microfarad, what is the capacitance of a standard parallel plate capacitor with plate separation of 1 micron and plate area of 1 meter squared?

ANSWER: 9



**TOSS-UP**

10) Math – *Multiple Choice* If  $n$  is an integer, and  $x^n$  is positive for all nonzero real numbers  $x$ , which of the following must be true about  $n$ ?

- W)  $n$  is greater than zero
- X)  $n$  does not equal zero
- Y)  $n$  is even
- Z)  $n$  is odd

ANSWER: Y)  $n$  IS EVEN

**BONUS**

10) Math – *Multiple Choice* Which of the following points lies in the solution set for the following system of two inequalities in two unknowns:  $3y - x \geq -9$  and  $3y - 2x < -9$ ?

- W) (3, 1)
- X) (4, -4)
- Y) (8, -2)
- Z) (8, 2)

ANSWER: Z) (8, 2)

### TOSS-UP

11) Earth and Space – *Multiple Choice* What type of geologic fault is characterized by upward displacement of a footwall?

- W) Normal
- X) Reverse
- Y) Strike-slip
- Z) Thrust

ANSWER: W) NORMAL

### BONUS

11) Earth and Space – *Short Answer* Identify all of the following three characteristics that can be used to distinguish the mineral calcite from the mineral quartz: 1) Color; 2) Hardness; 3) Birefringence [*bye-ree-FRIN-jents*].

ANSWER: 2 AND 3

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### TOSS-UP

12) Chemistry – *Multiple Choice* Which of the following functional groups is most likely to be formed when dodecane [*doh-DECK-ane*] undergoes "cracking?"

- W) Alcohol
- X) Aldehyde
- Y) Alkene
- Z) Amide

ANSWER: Y) ALKENE

### BONUS

12) Chemistry – *Short Answer* In diagrams of reaction mechanisms, the standard double-headed curved arrow represents the movement of what entities?

ANSWER: ELECTRONS (ACCEPT: ELECTRON PAIR, NEGATIVE CHARGES)

**TOSS-UP**

13) Biology – *Multiple Choice* Membrane depolarization of an action potential is able to pass from one cardiac cell to another through what type of connection between cells?

- W) Desmosomes
- X) Tight junction
- Y) Occluding junction
- Z) Gap junction

ANSWER: Z) GAP JUNCTION

**BONUS**

13) Biology – *Multiple Choice* Which of the following statements best describes the difference in responses of plasma cells and cytotoxic T-cells?

- W) Plasma cells respond the first time the invader is present, cytotoxic T-cells respond subsequent times
- X) Plasma cells execute the cell-mediated response, cytotoxic T-cells execute the humoral response
- Y) Plasma cells secrete antibodies against a pathogen, cytotoxic T-cells kill virus-infected cells
- Z) Plasma cells confer active immunity, cytotoxic T-cells confer passive immunity

ANSWER: Y) PLASMA CELLS SECRETE ANTIBODIES AGAINST A PATHOGEN, CYTOTOXIC T-CELLS KILL VIRUS-INFECTED CELLS



**TOSS-UP**

14) Math – *Multiple Choice* When working with three coordinate axes, what rule determines the orientation of the z-axis in relation to the x- and y-axes?

- W) Left-hand rule
- X) Octant rule
- Y) Right-hand rule
- Z) Three-space rule

ANSWER: Y) RIGHT-HAND RULE

**BONUS**

14) Math – *Short Answer* What number must be ADDED to both the numerator and denominator of  $\frac{3}{4}$  to get  $\frac{4}{3}$ ?

ANSWER: -7

**TOSS-UP**

15) Chemistry – *Short Answer* What property of concentration in chemistry is defined as moles of solute per kilograms of solvent and is useful when calculating freezing-point depression and boiling-point elevation?

ANSWER: MOLALITY (DO NOT ACCEPT: MOLARITY, NORMALITY)

**BONUS**

15) Chemistry – *Multiple Choice* Which of the following substances would you expect to be the most miscible with water?

- W) Methanol
- X) Ethyl acetate
- Y) 2-butanol
- Z) Butyraldehyde

ANSWER: W) METHANOL

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**TOSS-UP**

16) Earth and Space – *Multiple Choice* Bauxite, the hydroxide ore of aluminum, is mined primarily from deposits in tropical areas. What process causes these deposits to form?

- W) Chemical weathering
- X) Magmatic intrusion
- Y) Lake turnover
- Z) Metasomatism

ANSWER: W) CHEMICAL WEATHERING

**BONUS**

16) Earth and Space – *Short Answer* The Oso landslide that occurred in Washington State in 2014 moved 1.2 kilometers across the North Fork Stillaguamish [*STILL-ah-GWAH-mush*] River in a single minute. What was the speed of this landslide in miles per hour, rounded to the nearest tenth?

ANSWER: 44.7

**TOSS-UP**

17) Physics – *Short Answer* What electronic measuring instrument may be used as an ohmmeter, ammeter, or voltmeter?

ANSWER: MULTIMETER

**BONUS**

17) Physics – *Short Answer* To the nearest whole number of joules, what is the work done by gravity on a 500-gram ball that has rolled 20 meters down a 30-degree incline?

ANSWER: 49



**TOSS-UP**

18) Energy – *Multiple Choice* In what form can excess electrical energy be stored in a flywheel?

- W) Rotational kinetic energy
- X) Rotational potential energy
- Y) Translational momentum
- Z) Rotational gravitational energy

ANSWER: W) ROTATIONAL KINETIC ENERGY

**BONUS**

18) Energy – *Short Answer* What is the most commonly used material for the anode in commercial lithium-ion batteries?

ANSWER: GRAPHITE

**TOSS-UP**

19) Earth and Space – *Short Answer* What subsurface phenomenon, defined as soil that is perennially frozen, occurs beneath much of the state of Alaska and, as it melts, causes extensive damage of roads, trains, and pipelines?

ANSWER: PERMAFROST (ALSO ACCEPT: PERENNIALY CRYOTIC SOIL; DO NOT ACCEPT: CRYOTIC SOIL OR CRYOSOL)

**BONUS**

19) Earth and Space – *Multiple choice* In the distant future, the Andromeda Galaxy will collide with the Milky Way. Which of the following would a hypothetical alien presently living in Andromeda observe about Balmer lines from our galaxy?

- W) Their wavelengths are shorter than expected
- X) Their wavelengths are longer than expected
- Y) Their frequencies are lower than expected
- Z) They are not subject to Zeeman splitting

ANSWER: W) THEIR WAVELENGTHS ARE SHORTER THAN EXPECTED

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**TOSS-UP**

20) Math – *Short Answer* How many points of intersection do the graphs of the functions  $f(x) = -x^2$  and  $g(x) = 2$  raised to the  $x$  power have?

ANSWER: 0 (ACCEPT: NONE)

**BONUS**

20) Math – *Short Answer* The terminal side of an angle in standard position passes through the point (8, -15). Find the sine and tangent, respectively, of the angle.

ANSWER: SINE =  $-15/17$ , TANGENT =  $-15/8$  (ACCEPT:  $-1 \frac{7}{8}$ )

**TOSS-UP**

21) Physics – *Short Answer* A Carnot engine operates between a hot temperature of 527 degrees Celsius and a cold temperature of 127 degrees Celsius. What is its efficiency?

ANSWER: 50% (ACCEPT: 0.5, 1/2)

**BONUS**

21) Physics – *Short Answer* Three resistors are connected in parallel to a 10-amp DC current source. If the individual resistances are 5 ohms, 8 ohms and 20 ohms, what is the power, to the nearest watt, dissipated by the circuit?

ANSWER: 267



**TOSS-UP**

22) Biology – *Short Answer* Identify all of the following three statements that are true regarding lysosomes: 1) Lysosomal enzymes are active at acidic pH; 2) Lysosomes are implicated in inclusion-cell disease; 3) Lysosomes are formed from late endosomes.

ANSWER: 1, 2 AND 3

**BONUS**

22) Biology – *Short Answer* The term capnophile, used to describe a microbe, refers to the microbe's preference for environments high in what?

ANSWER: CARBON DIOXIDE (ACCEPT: CARBON DIOXIDE GAS or CO<sub>2</sub> or CO<sub>2</sub> GAS)

### TOSS-UP

23) Earth and Space – *Short Answer* What geologic eon extends from around 542 million years ago through the present day?

ANSWER: PHANEROZOIC

### BONUS

23) Earth and Space – *Multiple Choice* Global warming leads to positive feedbacks that accelerate the greenhouse effect. Which of the following is an example of this?

- W) Plants photosynthesize more efficiently in a CO<sub>2</sub>-rich atmosphere
- X) Reduced snow cover allows more solar radiation to warm the ground
- Y) More CO<sub>2</sub> is sequestered by rock weathering in a warmer atmosphere
- Z) A warmer Earth loses more radiation to space

ANSWER: X) REDUCED SNOW COVER ALLOWS MORE SOLAR RADIATION TO WARM THE GROUND