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TOSS-UP

1) CHEMISTRY *Short Answer* In a hydrogen fuel cell, two moles of H_2 are oxidized by one mole of O_2 to form two moles of water. If the cell is 100% efficient, how many moles of electrons are transferred in this process?

ANSWER: 4

BONUS

1) CHEMISTRY *Multiple Choice* The polymerization of a 1,3 diene *[DY-een]* will produce a material that can be used to make which of the following polymers?

W) Nylon
X) Rubber
Y) Styrene
Z) Thermoplastic

ANSWER: X) RUBBER

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TOSS-UP

2) BIOLOGY *Multiple Choice* Which of the following correctly describes why antifungal medications are often harder to design than antibacterials?

W) Antifungals must target peptidoglycan *[pep-ti-doh-GLY-kan]*
X) Both fungi and humans are eukaryotes *[yoo-KAR-ee-ohts]*
Y) Bacteria and humans have similar cellular structures
Z) Most antifungals target chitin building enzymes

ANSWER: X) BOTH FUNGI AND HUMANS ARE EUKARYOTES

BONUS

2) BIOLOGY *Multiple Choice* Tunicamycin *[too-ni-kuh-MY-sin]* is a drug produced by some bacteria. It is used as a tool by molecular biologists because it induces eukaryotic *[yoo-KAR-ee-oh-tik]* cells to arrest at the G1 checkpoint of the cell cycle. Using this information about tunicamycin and your knowledge of the cell cycle, which of the following would you expect to observe in a tunicamycin-arrested cell?

W) Activated APC protein
X) Chiasmata *[ky-AZ-muh-tuh]*
Y) Replication bubbles
Z) Spindle fibers

ANSWER: W) ACTIVATED APC PROTEIN

TOSS-UP

3) ENERGY *Multiple Choice* Power companies estimate the over-time cost of designing, building, operating, and decommissioning a power plant in order to calculate which of the following?

W) Intrinsic cost
X) Comprehensive fuel cost
Y) Levelized cost
Z) Future-versus-present earnings

ANSWER: Y) LEVELIZED COST

BONUS

3) ENERGY *Short Answer* Identify all of the following three changes that would increase the half-life of a first order reaction: 1) increasing the starting concentration; 2) decreasing the starting concentration; 3) increasing the rate constant.

ANSWER: 3 (ACCEPT: INCREASING THE RATE CONSTANT)
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TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Which of the following clays has the highest cation *[KAT-eye-uhn]* exchange capacity (CEC)?

W) Kaolinites *[KAY-uh-luh-nyts]*
X) Vermiculites *[ver-MIK-yoo-lyts]*
Y) Chlorides
Z) Allophanes

ANSWER: X) VERMICULITES

BONUS

4) EARTH AND SPACE *Short Answer* Which two planets in our solar system have the highest fraction of methane in their atmospheres?

ANSWER: NEPTUNE and URANUS

TOSS-UP

5) MATH *Multiple Choice* Which of the following is correct about the symmetry of even functions?

W) They are symmetric about the y-axis
X) They are symmetric about the x-axis
Y) They are symmetric about the origin
Z) They do not necessarily have symmetry

ANSWER: W) THEY ARE SYMMETRIC ABOUT THE y-AXIS

BONUS

5) MATH *Short Answer* For a line passing through the point (1, 0, -1) and parallel to the vector (2, 1, 4), give the parametric equations for x, y, and z.

ANSWER: $x = 1 + 2t, y = t, z = -1 + 4t$

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TOSS-UP

6) BIOLOGY *Multiple Choice* Amniotes became very well adapted to life on land. Which of the following is not an adaptation of amniotes to a terrestrial existence?

W) Eggs resistant to desiccation
X) Buccal pumping
Y) Water-conserving kidneys
Z) Thoracic breathing

ANSWER: X) BUCCAL PUMPING

BONUS

6) BIOLOGY *Multiple Choice* What facial muscle functions to enable blinking?

W) Zygomaticus *[zy-guh-MA-ti-kuhs]*
X) Orbicularis oculi *[or-bee-kyoo-LUH-ris]*
Y) Orbicularis oris
Z) Corrugator supercillii

ANSWER: X) ORBICULARIS OCULI

TOSS-UP

7) CHEMISTRY *Multiple Choice* "Soda-lime" glass accounts for 90% of the glass produced and can be made by mixing a modifier, or flux, with sand. Which of the following is an example of a soda-lime glass modifier?

W) SiO_2
X) $Ca(OH)_2$
Y) Na_2O
Z) MgO

ANSWER: Y) Na_2O

BONUS

7) CHEMISTRY *Short Answer* Categorize each of the following four examples of isomerism as either structural isomerism or stereoisomerism *[ster-ee-oh-EYE-suh-mer]*: 1) geometrical; 2) ionization; 3) polymerization *[puh-lim-er-uh-ZAY-shuhn]*; 4) optical.

ANSWER: STRUCTURAL ISOMERISM: 2, 3 (IONIZATION, POLYMERIZATION); STEREOISOMERISM: 1, 4 (GEOMETRICAL, OPTICAL)

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TOSS-UP

8) PHYSICS *Multiple Choice* Which of the following laws or principles gives a physical interpretation for the sign convention used in Faraday's law of induction?

W) Lenz's law
X) Ampere's law
Y) Coulomb's law
Z) Gauss's law

ANSWER: W) LENZ'S LAW

BONUS

8) PHYSICS *Short Answer* By number, give all of the following three statements that are true of Carnot engines: 1) Carnot's theorem limits the efficiency of engines to less than that of a Carnot engine; 2) The Carnot cycle consists of only reversible steps; 3) The concept of entropy arose from the limits stated by the Carnot cycle.

ANSWER: 1, 2, 3 (ACCEPT: ALL OF THEM)

TOSS-UP

9) EARTH AND SPACE *Multiple Choice* Which of the following describes the the ratio between the distance from a point to the center of a black hole and the circumference of a circle around the black hole?

W) Less than pi
X) Equal to pi
Y) Greater than pi
Z) Undefined

ANSWER: Z) UNDEFINED

BONUS

9) EARTH AND SPACE *Short Answer* How much volcanic material, in cubic kilometers, does a volcano have to eject to be considered an 8 on the Volcanic Explosivity Index, or VEI?

ANSWER: 1000

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TOSS-UP

10) BIOLOGY *Short Answer* What fluid, produced by ependymal cells, fills the space between the arachnoid *[uh-RAK-noid]* and the pia mater as well as the ventricles of the brain?

ANSWER: CEREBROSPINAL FLUID

BONUS

10) BIOLOGY *Multiple Choice* Bungarotoxin *[bung-garoh-TOK-sins]* is a fast-acting lethal toxin that is the primary component of venom from the South Asian snake called a krait. It blocks nerve transmission at cholinergic *[koh-luh-NUR-jik]* synapses by competing with acetylcholine *[uh-seet-l-KOH-leen]* to bind irreversibly at the acetylcholine receptor. Which of the following would be LEAST LIKELY to also impact nerve transmission at the cholinergic synapses?

W) A drug floods the synapse with a molecule that resembles acetylcholine and is able to bind at the acetylcholine receptor, but cannot be recognized by acetylcholinesterase *[uh-seet-l-KOH-leen-STUH-rays]*
X) A chemical covalently binds to the acetylcholine receptor and is not easily inactivated
Y) A chemical covalently bonds acetylcholinesterase at the enzyme active site
Z) A drug increases the level of acetylcholinesterase present at the synapse

ANSWER: Z) A DRUG INCREASES THE LEVEL OF ACETYLCHOLINESTERASE PRESENT AT THE SYNAPSE

TOSS-UP

11) MATH *Short Answer* Under what arithmetic operation is the set of even integers NOT closed?

ANSWER: DIVISION

BONUS

11) MATH *Short Answer* An object is moving along a line in such a way that its position s at time t seconds is given by $s = 4t^3 - 12t^2 + 24t$ **[s equals four t cubed minus twelve t squared plus twenty-four t]**. Determine the minimum velocity of the object, in units per second.

ANSWER: 12

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TOSS-UP

12) ENERGY *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 **[gly-KOL-uh-sis]**
Z) Beta oxidation

ANSWER: W) CYCLIC ELECTRON FLOW

BONUS

12) ENERGY *Short Answer* Assume we have two inlets to a hydroelectric plant's turbines: one inlet is at 50 m depth, and the second inlet is at 80 m depth. How much greater, by percentage, is the pressure at the deeper compared to the shallower one?

ANSWER: 60% GREATER (ACCEPT: 60%)

TOSS-UP

13) CHEMISTRY *Short Answer* Identify all of the following four types of reactions that follow Zaitsev's rule: 1) S_N1; 2) S_N2; 3) E1; 4) E2

ANSWER: 3 and 4 (ACCEPT: E1 and E2)

BONUS

13) CHEMISTRY *Short Answer* Identify all of the following three statements that are true of nuclear chemistry: 1) Helium has a higher binding energy per nucleon than uranium; 2) Alpha particles have a +1 charge; 3) Beta-minus decay usually occurs in nuclei with an excess number of neutrons.

ANSWER: 3 ONLY (ACCEPT: BETA-MINUS DECAY USUALLY OCCURS IN NUCLEI WITH AN EXCESS NUMBER OF NEUTRONS)

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TOSS-UP

14) BIOLOGY *Multiple Choice* All except which of the following can act as direct substrates for the production of acetyl CoA?

W) Lactate
X) Amino acids
Y) Fatty acids
Z) Ketone bodies

ANSWER: W) LACTATE

BONUS

14) BIOLOGY *Multiple Choice* Which of the following enzymes is unique to gluconeogenesis *[gloo-koh-nee-uh-JEN-uh-sis]*?

W) PEP carboxykinase *[kahr-bok-si-KY-nays]*
X) Pyruvate kinase *[py-ROO-vayt]*
Y) Hexokinase *[hek-soh-KY-nays]*
Z) Phosphofructokinase *[fohs-foh-frook-toh-KY-nays]*

ANSWER: W) PEP CARBOXYKINASE

TOSS-UP

15) EARTH AND SPACE *Short Answer* What is the name for the topography that is created through extension of crust, producing distinct horsts and grabens?

ANSWER: BASIN AND RANGE

BONUS

15) EARTH AND SPACE *Multiple Choice* In the unified model of active galactic nuclei (AGN), what is the most important variable that determines what class of AGN is observed?

W) Orientation angle
X) Metallicity
Y) Supermassive black hole age
Z) Galaxy type

ANSWER: W) ORIENTATION ANGLE

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TOSS-UP

16) ENERGY *Short Answer* The presence of what class of compounds in nuclear reactors slows down the neutrons in the core, preventing the development of a potential nuclear bomb?

ANSWER: MODERATORS (DO NOT ACCEPT: CONTROL RODS)

BONUS

16) ENERGY *Short Answer* What extremely powerful biological oxidizing agent is used in photosynthesis to oxidize water and is named for its absorption maximum in the red part of the visible spectrum?

ANSWER: P680 (ACCEPT: PIGMENT 680)

TOSS-UP

17) MATH *Multiple Choice* Two spheres with radii *[RAY-dee-y]* of 2 and 8 are resting on a tabletop so that they are touching. How far apart are their points of contact on the table?

W) 2
X) 4
Y) 8
Z) 9

ANSWER: Y) 8

BONUS

17) MATH *Short Answer* You are given that $xy = 6$ and $x^2y + xy^2 + x + y = 63$ *[x times y equals six and x squared times y plus x times y squared plus x plus y equals sixty-three]*. Calculate: $x^2 + y^2$ *[x squared plus y squared]*.

ANSWER: 69

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TOSS-UP

18) PHYSICS *Short Answer* Identify all of the following three experiments that demonstrate the particle nature of light: 1) photoelectric effect; 2) dual-slit experiment; 3) Davisson-Germer experiment.

ANSWER: 1 (ACCEPT: PHOTOELECTRIC EFFECT)

BONUS

18) PHYSICS *Multiple Choice* Which of the following is NOT featured in the Bohr model of the atom?

W) Quantized energy levels
X) Densely packed nucleus
Y) Atomic orbitals
Z) Electrostatic attraction

ANSWER: Y) ATOMIC ORBITALS

TOSS-UP

19) BIOLOGY *Multiple Choice* During starvation, muscles convert most of the amino acids released from muscle breakdown to what two specific amino acids for use in gluconeogenesis *[gloo-koh-nee-uh-JEN-uh-sis]*?

W) Arginine and glycine *[AHR-juh-neen]*
X) Arginine and glutamine
Y) Alanine and glutamine
Z) Glutamine and glycine *[GLY-seen]*

ANSWER: Y) ALANINE AND GLUTAMINE

BONUS

19) BIOLOGY *Multiple Choice* If you were to selectively extract protein molecules from the H-zone of a sarcomere *[SAHR-kuh-meer]*, which of the following would be found in the extract?

W) Actin
X) Myosin *[MY-uh-sin]*
Y) Titin
Z) Tropomyosin *[troh-puh-mee-UH-sin]*

ANSWER: X) MYOSIN

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TOSS-UP

20) CHEMISTRY *Short Answer* Identify all of the following four elements that would burn red when subjected to a flame test: 1) lithium; 2) selenium; 3) barium; 4) calcium.

ANSWER: 1 AND 4 (ACCEPT: LITHIUM AND CALCIUM)

BONUS

20) CHEMISTRY *Short Answer* A particular polymer has a chain length of 8. If the same conditions were used to create another polymer, with the only difference being that a difunctional initiator will be used, what would the resulting chain length be?

ANSWER: 16

TOSS-UP

21) MATH *Short Answer* Two planes are orthogonal to each other. How many lines exist that are a given fixed distance *d* from both of these planes?

ANSWER: FOUR

BONUS

21) MATH *Short Answer* Evaluate the following expression: $\sum_{n=1}^{14} n^2$ *[the sum from n equals one to fourteen of n squared]*

ANSWER: 1015

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TOSS-UP

22) PHYSICS *Short Answer* By number rank the following three systems of materials, from lowest to highest, in terms of their coefficients of kinetic friction: 1) rubber on concrete; 2) human joints; 3) ice on ice.

ANSWER: 2, 3, 1

BONUS

22) PHYSICS *Multiple Choice* Which of the following statements is correct about the behavior of black bodies?

W) At high enough temperatures, black bodies will stop emitting in the microwave region
X) The Stefan-Boltzmann law relates the power radiated by a black body to temperature squared
Y) Approximating a human as a black body shows that most of a person's energy is radiated away as ultraviolet light
Z) Wien's law can be used to predict the color of a black body

ANSWER: Z) WIEN'S LAW CAN BE USED TO PREDICT THE COLOR OF A BLACK BODY

TOSS-UP

23) EARTH AND SPACE *Multiple Choice* What was the principle reason that the Kapteyn model and the Shapley model of the size of the Galaxy were incorrect?

W) They only examined the distribution of stars and failed to examine the distribution of globular clusters
X) They used data that was not sensitive enough to detect the faintest stars in the Galaxy
Y) They failed to account for extinction due to dust
Z) They only examined the distribution of globular clusters and failed to examine the distribution of stars

ANSWER: Y) THEY FAILED TO ACCOUNT FOR EXTINCTION DUE TO DUST

BONUS

23) EARTH AND SPACE *Multiple Choice* Which of the following sets of values best approximates an average micrite limestone in a ternary diagram with end members (1) allochemical grains, (2) chemical cement, (3) microcrystalline matrix?

W) (1) 10%,(2) 90%, (3) 0%
X) (1) 25%, (2) 0%, (3) 75%
Y) (1) 75%, (2) 10%, (3) 15%
Z) (1) 50%, (2) 45%, (3) 5%

ANSWER: X) (1)25%, (2) 0%, (3) 75%