ROUND 16

TOSS-UP

1) BIOLOGY *Short Answer* Name the taxonomic order in which the gharial *[GUHR-ee-uhl]* or gavial *[GAY-vee-uhl]*, *Gavialis gangeticus [ga-vee-AL-is gan-JET-uh-kuhs]*, is found.

ANSWER: CROCODILIA

BONUS

1) BIOLOGY *Short Answer* Identify all of the following four cranial nerves that have a purely somatic motor function: 1) Trigeminal *[try-JEM-uh-nl]*, 2) Trochlear *[TROK-lee-er]*, 3) Hypoglossal, 4) Glossopharyngeal *[glos-oh-fuh-RIN-jee-uhl]*.

ANSWER: 2 AND 3 (ACCEPT: TROCHLEAR, HYPOGLOSSAL)

TOSS-UP

2) PHYSICS *Multiple Choice* Assuming g = 10 meters per second squared and the density of freshwater is 1000 kilograms per cubic meter, what is the buoyancy force in newtons exerted on a rock with mass of 100 kilograms and a volume of 10,000 cubic centimeters sitting at the bottom of a freshwater lake?

W) 10
X) 100
Y) 1000
Z) 10000

ANSWER: X) 100

BONUS

2) PHYSICS *Multiple Choice* Which of the following best estimates the momentum carried by an electromagnetic wave with energy of 30 joules?

W) 10^{-7}
X) 10^{-5}
Y) 3×10^{-7}
Z) 9×10^{-5}

ANSWER: W) 10^{-7}

TOSS-UP

3) MATH *Multiple Choice* The points on a scatter plot are extremely close to their least-squares regression line, which is expressed by the equation $y = -2x + 3$. The correlation coefficient r between x and y is closest to which of the following?

W) -2
X) -1
Y) 1/2
Z) 1

ANSWER: X) -1

BONUS

3) MATH *Short Answer* For the implicit function $xy^2 + x^3y = 2$, what is the slope of its tangent line at the point (1, 1)?

ANSWER: -4/3

TOSS-UP

4) ENERGY *Multiple Choice* Why do solid oxide fuel cells not require a precious metal catalyst or fuel reformer?

W) They do not rely on the hydrogen-oxygen redox couple
X) They have a high operating temperature
Y) They have a very fast startup time
Z) They have a low operating temperature

ANSWER: X) THEY HAVE A HIGH OPERATING TEMPERATURE

BONUS

4) ENERGY *Short Answer* Graphene sheets, often used in solar cells and capacitors, have carbon rings with which type of lattice?

ANSWER: HEXAGONAL (ACCEPT: HONEYCOMB)

TOSS-UP

5) EARTH AND SPACE *Multiple Choice* The Burgess Shale, in the Canadian Rockies, is best known for which of the following fossils?

W) Proterozoic terrestrial plant *[prot-er-uh-ZOH-ik]*
X) Cambrian marine
Y) K/T boundary dinosaur
Z) Peat bog human

ANSWER: X) CAMBRIAN MARINE

BONUS

5) EARTH AND SPACE *Short Answer* To the nearest 10, how many times has the Sun orbited the galaxy since the Sun formed?

ANSWER: 20

TOSS-UP

6) CHEMISTRY *Short Answer* Organolithium *[ohr-guh-noh-LITH-ee-uhm]* reagents can be reacted with salts made from which element to form a Gilman reagent? Specify both the element and its oxidation state.

ANSWER: COPPER 1+ (ACCEPT: COPPER, 1)

BONUS

6) CHEMISTRY *Short Answer* Catalytic cracking is the most commonly used process in the manufacture of olefins. Different products can be produced from different reactants. If you want to produce an aromatic through cracking followed by dehydration, with what reactant should you begin?

ANSWER: NAPHTHENE(S) (ACCEPT: CYCLOALKANE(S))

TOSS-UP

7) BIOLOGY *Short Answer* Of the 20 amino acids encoded by the universal genetic code, only one is technically an imino acid, as the R-group is covalently bonded to the amino terminus to form a nitrogen-containing ring. Unless it is modified, this amino acid also tends to disrupt secondary structures such as alpha-helices and beta sheets if it is found in the middle of them. What is this amino acid?

ANSWER: PROLINE

BONUS

7) BIOLOGY *Multiple Choice* What is the predicted size in billions of base pairs of the woolly-mammoth genome?

W) 1
X) 4
Y) 33
Z) 100

ANSWER: X) 4

TOSS-UP

8) PHYSICS *Multiple Choice* Given R = 1.097 × 10^7 inverse meters, which of the following represents the wavelength of the longest wavelength Lyman line of the hydrogen spectrum in meters and the region of the electromagnetic spectrum in which it lies?

W) 1.22 × 10^{-7}; ultraviolet
X) 1.22 × 10^{-7}; visible
Y) 1.22 × 10^{-6}; infrared
Z) 1.22 × 10^{-6}; visible

ANSWER: W) 1.22 × 10^{-7}; ULTRAVIOLET

BONUS

8) PHYSICS *Multiple Choice* Assuming a metabolic rate of 500 watts, how much energy in joules is transformed by a 70 kilogram person while exercising for 1 hour?

W) 1500
X) 1.8 million
Y) 5 .4 million
Z) 6.3 trillion

ANSWER: X) 1.8 MILLION

TOSS-UP

9) MATH *Multiple Choice* What is $\lim_{x \to \pi} \frac{\sin x}{x - \pi}$ *[the limit as x approaches pi of the fraction with numerator sine of x and denominator x minus pi]*?

W) -1
X) 0
Y) 1
Z) Undefined

ANSWER: W) -1

BONUS

9) MATH *Multiple Choice* The line determined by points $(0, 2b)$ and $(2a, 0)$ intersects the line determined by points $(0, b)$ and (a, b). What represents the *x*-value of the point where the two lines intersect?

W) a
X) $2a$
Y) $a + b$
Z) b/a

ANSWER: W) a

TOSS-UP

10) ENERGY *Multiple Choice* What is the typical hub height in meters of a utility-scale wind turbine?

W) 80
X) 160
Y) 240
Z) 320

ANSWER: W) 80

BONUS

10) ENERGY *Short Answer* By number, rank the thermal resistance of the following four insulation materials from greatest to least: 1) Glass, 2) Closed-cell polyurethane *[pol-ee-YOOR-uh-thayn]* spray foam, 3) Polystyrene *[pol-ee-STY-reen]* board, 4) Fiberglass batts.

ANSWER: 2, 3, 4, 1

TOSS-UP

11) EARTH AND SPACE *Multiple Choice* Scientists currently believe that modern birds descended from what organisms?

W) Pterosaurs *[TER-uh-sawrs]*
X) Ornithopods
Y) Therapods
Z) Sauropods

ANSWER: Y) THERAPODS

BONUS

11) EARTH AND SPACE *Multiple Choice* When the Milky Way and Andromeda galaxies merge, which of the following is closest to the number of pairs of stars that are expected to collide?

W) 1
X) 100
Y) 10,000
Z) 1,000,000

ANSWER: W) 1

TOSS-UP

12) CHEMISTRY *Multiple Choice* Which of the following spectral series has a final energy level of 4?

W) Paschen *[PA-shen]*
X) Brackett
Y) Pfund *[PFOONT]*
Z) Lyman

ANSWER: X) BRACKETT

BONUS

12) CHEMISTRY *Short Answer* Place the following four solvents in order of fastest to slowest reaction rate for S_N2: 1) water, 2) DMSO, 3) methanol, 4) acetonitrile *[as-i-toh-NY-tril]*.

ANSWER: 4, 2, 1, 3 (ACCEPT: ACETONITRILE, DMSO, WATER, METHANOL)

TOSS-UP

13) BIOLOGY *Short Answer* In segmented animals, a specific family of genes is particularly important for directing the orientation and placement of structures and segments. These genes encode transcription factors that are able to bind a regulatory region of DNA called the homeobox. Name this gene family.

ANSWER: HOX

BONUS

13) BIOLOGY *Multiple Choice* Which of the following is true about reverse phase chromatography?

W) The stationary phase is hydrophilic *[hy-druh-FIL-ik]*
X) The stationary phase is acidic
Y) It is typically used for separation of proteins
Z) The stationary phase is hydrophobic

ANSWER: Z) THE STATIONARY PHASE IS HYDROPHOBIC

TOSS-UP

14) PHYSICS *Multiple Choice* What is the speed of a particle that has a Lorentz factor of 3.0?

W) $2c\sqrt{3}$
X) $(3c\sqrt{2})/2$
Y) $(2c\sqrt{2})/3$
Z) $(c\sqrt{2})/3$

ANSWER: Y) $(2c\sqrt{2})/3$

BONUS

14) PHYSICS *Multiple Choice* A sports car driver slams the brakes and the car slows from 90 miles per hour to a complete stop in 4 seconds. In terms of *g*, which of the following is closest to the car's acceleration?

W) -0.5 *g*
X) -*g*
Y) -2*g*
Z) -5*g*

ANSWER: X) -*g*

TOSS-UP

15) MATH *Short Answer* Find an antiderivative for $ln(e^{-x^2})$ *[the natural log of the quantity e to the power of negative x squared]*.

ANSWER: $-(1/3)x^3$ (ACCEPT: GIVEN ANSWER PLUS ANY CONSTANT)

BONUS

15) MATH *Short Answer* A curve is defined parametrically by $x = \cos t$ *[x equals cosine of t]* and $y = \tan t$ *[y equals tangent of t].* What is dy/dx when $t = \pi/6$?

ANSWER: -8/3

TOSS-UP

16) ENERGY *Multiple Choice* As you turn on your flashlight, its lithium-ion battery begins to discharge. What happens to the electrons and ions inside the battery?

W) Both the electrons and the lithium ions move towards the cathode
X) Both the electrons and the lithium ions move towards the anode
Y) The electrons move towards the cathode while the lithium ions move towards the anode
Z) The electrons move towards the anode while the lithium ions move towards the cathode

ANSWER: W) BOTH THE ELECTRONS AND THE LITHIUM IONS MOVE TOWARDS THE CATHODE

BONUS

16) ENERGY *Short Answer* If a city had a yearly load of 438,000 megawatt hours and built a power plant with a capacity factor of 50%, what would the nameplate capacity have to be in megawatts in order to meet total load?

ANSWER: 100

TOSS-UP

17) EARTH AND SPACE *Multiple Choice* In which of the following ways does the mineral biotite *[BY-uh-tyt]* differ from the mineral muscovite *[MUHS-kuh-vyt]*?

W) Biotite contains silica while muscovite does not
X) Muscovite contains potassium while biotite does not
Y) While both contain aluminum, only biotite contains magnesium
Z) While both contain sodium, only muscovite contains aluminum

ANSWER: Y) WHILE BOTH CONTAIN ALUMINUM, ONLY BIOTITE CONTAINS MAGNESIUM

BONUS

17) EARTH AND SPACE *Short Answer* Arrange the following four Big Bang events in chronological order: 1) nucleosynthesis, 2) reionization, 3) recombination, 4) inflation.

ANSWER: 4, 1, 3, 2 (ACCEPT: INFLATION, NUCLEOSYNTHESIS, RECOMBINATION, REIONIZATION)

TOSS-UP

18) CHEMISTRY *Multiple Choice* Which of the following protein purification techniques coats proteins with a negative charge after they are denatured?

W) Affinity chromatography
X) Isoelectric focusing
Y) SDS-PAGE
Z) Ion exchange chromatography

ANSWER: Y) SDS-PAGE

BONUS

18) CHEMISTRY *Multiple Choice* You are studying a material that has started to undergo thermal fatigue. Which of the following would be a good action to take to reduce this fatigue?

W) Eliminate loading by design
X) Add protective surface coating
Y) Decrease corrosiveness of medium
Z) Add residual compressive stresses

ANSWER: W) ELIMINATE LOADING BY DESIGN

19) BIOLOGY *Multiple Choice* In which of the following cell processes would caspase activity most likely occur?

W) Mitosis *[my-TOH-sis]*
X) Apoptosis
Y) DNA replication
Z) Phagocytosis *[fag-uh-sy-TOH-sis]*

ANSWER: X) APOPTOSIS

BONUS

19) BIOLOGY *Short Answer* By number, identify all of the following four phrases that would NOT be indicative of a healthy stream ecosystem: 1) woody riparian zone that is equal to or greater than stream width; 2) abundant algal mats in stream channel; 3) stream channel with abundant large rocks and old logs; 4) banks unstable with easily disturbed loose soil.

ANSWER: 2, 4

TOSS-UP

20) PHYSICS *Multiple Choice* Which of the following is the correct relationship of half-life $T_{1/2}$ and mean life τ *[tau]* of an unstable particle, if λ *[lambda]* is the decay constant?

W) $T_{1/2} = \lambda/\tau$ *[Half-life equals lambda over tau]*
X) $T_{1/2} = \tau/\lambda$ *[Half-life equals tau over lambda]*
Y) $T_{1/2} = \tau \log_2 e$ *[Half-life equals tau log base 2 of e]*
Z) $T_{1/2} = \tau \ln (2)$ *[Half-life equals tau natural log of 2]*

ANSWER: Z) $T_{1/2} = \tau \ln (2)$

BONUS

20) PHYSICS *Multiple Choice* What is the image position in centimeters of a narrow object placed 100 centimeters from a 50 centimeter focal length lens?

W) 20
X) 25
Y) 50
Z) 100

ANSWER: Z) 100

21) MATH *Multiple Choice* What is the largest possible real domain of the function $h(x) = \ln(x^2 - 9)$ *[h of x equals the natural log of the quantity x squared minus 9]*?

W) $(-\infty, \infty)$
X) $(-\infty, -3) \cup (3, \infty)$ *[the open interval from negative infinity to negative 3 union the open interval from 3 to positive infinity]*
Y) $(-3, 3)$
Z) $(3, \infty)$

ANSWER: X) $(-\infty, -3) \cup (3, \infty)$

BONUS

21) MATH *Short Answer* Solve the following equation for *x* over the interval $0 \leq x < 2\pi$: $2\sin^2 x - \sin x - 1 = 0$ *[2 sine squared of x minus sine of x minus 1 equals 0]*.

ANSWER: $\pi/2$, $7\pi/6$, AND $11\pi/6$

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* The interstellar medium is primarily composed of two components, a warm ionized phase and a cool neutral phase. Which of the following is approximately the temperature in Kelvin of the cool phase?

W) 1
X) 10
Y) 100
Z) 1000

ANSWER: Y) 100

BONUS

22) EARTH AND SPACE *Multiple Choice* Which of the following geometries is inconsistent with a flat universe?

W) Infinite
X) Toroidal *[toh-ROID-l]*
Y) Horn
Z) Conical

ANSWER: Y) HORN

23) CHEMISTRY *Multiple Choice* A variety of manufacturing processes may be employed in nanotechnology. Which of the following processes can coat almost anything by transferring material from its source to the substrate without changing chemical composition?

W) E-beam
X) Nanoscale printing
Y) Vapor deposition
Z) Soft lithography

ANSWER: Y) VAPOR DEPOSITION

BONUS

23) CHEMISTRY *Short Answer* Arrange the following three methods of solvent degassing in order from least effective to most effective: 1) atmosphere exchange under sonication, 2) purging, 3) freeze-pump-thaw.

ANSWER: 2, 1, 3 (ACCEPT: PURGING, ATMOSPHERE EXCHANGE UNDER SONICATION, FREEZE-PUMP-THAW)

TOSS-UP

24) BIOLOGY *Multiple Choice* Lysosomes *[LY-suh-sohms]* are membrane-enclosed organelles in a cell containing an array of enzymes. Which of the following is closest to the pH of these vesicles?

W) 5
X) 6
Y) 7
Z) 8

ANSWER: W) 5

BONUS

24) BIOLOGY *Short Answer* With regard to the maturation of an erythrocyte *[ih-RITH-ruh-syt]*, arrange the following four choices in correct sequence starting with the cell type after the proerythroblast *[proh-i-RITH-ruh-blast]* and ending with the mature erythrocyte: 1) Basophilic *[bay-suh-FIL-ik]* erythroblast, 2) Reticulocyte *[ri-TIK-yoo-luh-syt]*, 3) Orthochromatic *[ohr-thuh-kroh-MAT-ik]* normoblast, 4) Polychromatophilic *[poh-lee-kroh-muh-tuh-fil-ik]* erythroblast.

ANSWER: 1, 4, 3, 2 (ACCEPT: BASOPHILIC ERYTHROBLAST, POLYCHROMATOPHILIC ERYTHROBLAST, ORTHOCHROMATIC NORMOBLAST, RETICULOCYTE)

TOSS-UP

25) PHYSICS *Multiple Choice* In a nuclear plant, 1 kilogram of mass is converted to energy. Given c = 3 x 10^8 meters per second, how much energy would be produced?

W) 9 megajoules
X) 9 gigajoules
Y) 3 terajoules
Z) 90 petajoules

ANSWER: Z) 90 PETAJOULES

BONUS

25) PHYSICS *Multiple Choice* Bats find their prey in the dark via echolocation *[ek-oh-loh-KAY-shuhn]*. Given that the speed of sound is 300 meters per second, if a bat emits a chirp at a frequency of 66 kilohertz, what is the smallest size of insect in millimeters it is able to detect?

W) 0.2
X) 1
Y) 5
Z) 16

ANSWER: Y) 5