

ROUND 10

TOSS-UP

1) CHEMISTRY *Short Answer* What is the most reduced symmetry operation symbol for a molecule that has a rotation angle of 240° ?

ANSWER: C_3^2

BONUS

1) CHEMISTRY *Short Answer* How many translational, rotational, and vibrational modes, respectively, are there for the molecule beryllium fluoride?

ANSWER: TRANSLATIONAL = 3; ROTATIONAL = 2; VIBRATIONAL = 4

TOSS-UP

2) MATH *Short Answer* Find the sum of the two solutions for the quadratic equation:
 $2x^2 - 4x + 8 = 0$.

ANSWER: 2

BONUS

2) MATH *Short Answer* Find the following limit: $\lim_{x \rightarrow 2} \frac{x^5 - 32}{x^4 - 16}$ **[the limit as x approaches 2 of the fraction with numerator x to the fifth minus 32 and denominator x to the fourth minus 16].**

ANSWER: $5/2$ (ACCEPT: $2 \frac{1}{2}$ OR 2.5)

TOSS-UP

3) EARTH AND SPACE *Multiple Choice* Which of the following is nearest the percentage of the Earth's surface that is covered by glaciers?

- W) 1%
- X) 5%
- Y) 10%
- Z) 20%

ANSWER: Y) 10%

BONUS

3) EARTH AND SPACE *Multiple Choice* Which of the following organisms was NOT present in the Jurassic?

- W) Triceratops
- X) Ichthyosaurs [*IK-thee-uh-sawrs*]
- Y) Dinoflagellates [*din-uh-FLAJ-uh-layts*]
- Z) Ginkgoes [*GING-kohs*]

ANSWER: W) TRICERATOPS

TOSS-UP

4) PHYSICS *Short Answer* If it takes 60 pounds-force to loosen a lug nut with a 5 inch wrench, how much force in pounds-force would it take if you used a 12 inch wrench instead?

ANSWER: 25

BONUS

4) PHYSICS *Multiple Choice* On a sunny clear day, the sky seems to be bluer directly overhead than it does toward the horizon. Which of the following is the reason?

- W) Light from the Sun undergoes more scattering with distance
- X) The atmosphere has higher density at the zenith versus closer to the Earth's surface
- Y) There is more oxygen in the air closer to the Earth's surface than high in the atmosphere
- Z) The upper atmosphere is colder than the Earth's surface

ANSWER: W) LIGHT FROM THE SUN UNDERGOES MORE SCATTERING WITH DISTANCE

TOSS-UP

5) ENERGY *Multiple Choice* By what process is gasoline separated from crude oil?

- W) Distillation
- X) Digestion
- Y) Fracking
- Z) Filtering

ANSWER: W) DISTILLATION

BONUS

5) ENERGY *Short Answer* What property of water allows it to have surface tension, and what is the intermolecular force responsible?

ANSWER: COHESION AND HYDROGEN BONDING

TOSS-UP

6) BIOLOGY *Short Answer* What is the process by which bacterial genes can be transferred from one bacterium to another via bacteriophages [*bak-TEER-ee-uh-FAY-juhs*]?

ANSWER: TRANSDUCTION

BONUS

6) BIOLOGY *Short Answer* In Labrador retrievers, coat color is determined by two sets of genes on different loci [*LOH-sy*]. At one locus, the upper case B allele [*uh-LEEL*] codes for black coat color, and the lower case b allele codes for brown coat pigment. At the second locus, the upper case E allele codes for the presence of a transporter to carry pigment to the hair shaft and the lower case e allele codes for the absence of the transporter. In the presence of transporter, the dog is black or brown; in the absence of transporter, the dog is yellow. What is the genotype of a yellow dog that is heterozygous for the brown allele?

ANSWER: Bbee (ACCEPT: bBee)

TOSS-UP

7) CHEMISTRY *Multiple Choice* Which of the following statements about visible energy transitions in electronic spectroscopy is NOT true?

- W) They are low energy transitions
- X) They occur between d-orbitals of transition metals
- Y) They occur between metal and ligand orbitals
- Z) They occur between ligand orbitals

ANSWER: Z) THEY OCCUR BETWEEN LIGAND ORBITALS

BONUS

7) CHEMISTRY *Multiple Choice* Propranolol [*proh-PRAN-uh-lol*] hydrochloride is a stable solid that belongs to a class of molecules known as beta blockers, and is prescribed as a racemic [*ray-SEE-mik*] mixture. Which of the following is NOT true with respect to propranolol hydrochloride?

- W) It will not rotate plane-polarized light
- X) It is optically pure
- Y) It is achiral [*ay-KY-ruhl*]
- Z) It includes equal amounts of each enantiomer [*i-NAN-tee-uh-mer*]

ANSWER: X) IT IS OPTICALLY PURE

TOSS-UP

8) MATH *Short Answer* Starting with point (4, 2) in the coordinate plane, reflect it across the x-axis, then rotate it 180° around the origin, and finally, translate it vertically up by 2 units. What are the coordinates of the point's final location?

ANSWER: (-4, 4)

BONUS

8) MATH *Short Answer* If $z_1 = 4 + 3i$ and $z_2 = i^3$, find the product of z_1 , z_2 , and the conjugate of z_1 .

ANSWER: $-25i$

TOSS-UP

9) EARTH AND SPACE *Multiple Choice* The San Andreas Fault and collision of India with Asia occurred in what geologic period?

- W) Cambrian
- X) Permian
- Y) Cretaceous [*kri-TAY-shuhs*]
- Z) Oligocene [*OL-i-goh-seen*]

ANSWER: Z) OLIGOCENE

BONUS

9) EARTH AND SPACE *Short Answer* What is the name of the largest aquifer [*AK-wuh-fer*] in the United States that underlies most of the Midwest?

ANSWER: OGALLALA AQUIFER

TOSS-UP

10) PHYSICS *Multiple Choice* The messenger particles of weak interaction are which of the following?

- W) Z bosons only
- X) W^+ and W^- bosons only
- Y) Z, W^+ , and W^- bosons
- Z) Virtual photons

ANSWER: Y) Z, W^+ , AND W^- BOSONS

BONUS

10) PHYSICS *Multiple Choice* A transformer has a primary coil with 10 loops and a secondary coil with 100 loops. If the primary coil is supplied with a household voltage of 100 volts and current of 10 amperes, what is the maximum voltage, in volts, across an open circuit produced in the secondary circuit?

- W) 10
- X) 100
- Y) 1000
- Z) 10,000

ANSWER: Y) 1000

TOSS-UP

11) BIOLOGY *Short Answer* The following four terms would apply to what group of organisms: primaries, axillars, coverts, scapulars?

ANSWER: BIRDS

BONUS

11) BIOLOGY *Multiple Choice* When a gene is duplicated within an organism to generate a second copy of that gene, what term in genomics would describe the relationship between the genes?

- W) Paralogous
- X) Orthologous
- Y) Syntologous
- Z) Heterologous

ANSWER: W) PARALOGOUS

TOSS-UP

12) CHEMISTRY *Short Answer* Providing your answer as a whole number, what is the overall order of the reaction governed by the rate law $R = k[\text{NO}_2]^2[\text{Br}_2]$ [*R equals k times the concentration of N-O-2 squared times the concentration of bromine*]?

ANSWER: 3 (ACCEPT: THIRD OR THIRD ORDER)

BONUS

12) CHEMISTRY *Short Answer* Hydrogen and chlorine are reacted in a 500 milliliter flask to form hydrogen chloride. It takes 0.08 seconds for the amount of chlorine to change by -0.005 moles. Providing your answers as decimals, determine the rate of conversion, in moles per second, and the rate of reaction, in molarity per second.

ANSWER: RATE OF CONVERSION = 0.0625; RATE OF REACTION = 0.125

TOSS-UP

13) PHYSICS *Multiple Choice* If object A and object B are in thermal equilibrium, and object B and object C are in thermal equilibrium, then object A and object C are also in thermal equilibrium. This situation is an example of what law of thermodynamics?

- W) Zeroth
- X) First
- Y) Second
- Z) Third

ANSWER: W) ZEROTH

BONUS

13) PHYSICS *Multiple Choice* Which of the following is nearest escape velocity on the surface of the Earth, in miles per hour?

- W) 1000
- X) 25,000
- Y) 66,000
- Z) 670 million

ANSWER: X) 25,000

TOSS-UP

14) MATH *Short Answer* What is the area of the region bounded by the curve: $y = \sin x$ [**y equals sine of x**] and the x-axis from $x = 0$ to $x = \pi$?

ANSWER: 2

BONUS

14) MATH *Short Answer* What is the largest possible real domain for the function $f(x) = (4x^2)/\sqrt{4 - x^2}$ [**f of x equals the fraction with numerator 4 x squared and denominator the square root of the quantity 4 minus x squared**]?

ANSWER: (-2, 2) (ACCEPT: $-2 < x < 2$)

TOSS-UP

15) EARTH AND SPACE *Multiple Choice* The Volcanic Explosivity Index rated the Toba eruption as an 8, the highest rating. Which of the following environments was the most likely tectonic setting for this eruption?

- W) Hot spot
- X) Subduction zone
- Y) Triple junction
- Z) Mid-ocean ridge

ANSWER: X) SUBDUCTION ZONE

BONUS

15) EARTH AND SPACE *Multiple Choice* Which of the following minerals is NOT a polymorph of Al_2SiO_5 ?

- W) Andalusite [**an-dl-OO-syt**]
- X) Aragonite [**uh-RAG-uh-nyt**]
- Y) Sillimanite [**SIL-uh-muh-nyt**]
- Z) Kyanite [**KAY-uh-nyt**]

ANSWER: X) ARAGONITE

TOSS-UP

16) ENERGY *Multiple Choice* Which of the following processes is currently used commercially to enrich uranium in the United States?

- W) Gaseous diffusion
- X) Gaseous centrifugation
- Y) Metal plating
- Z) Electrolysis

ANSWER: W) GASEOUS DIFFUSION

BONUS

16) ENERGY *Multiple Choice* Solvent-based techniques best capture carbon dioxide under which of the following relative conditions?

- W) High temperature, high pressure
- X) High temperature, low pressure
- Y) Low temperature, high pressure
- Z) Low temperature, low pressure

ANSWER: Y) LOW TEMPERATURE, HIGH PRESSURE

TOSS-UP

17) PHYSICS *Multiple Choice* Fluid pressure is caused by which of the following?

- W) Gravitational interactions among atoms and molecules of the fluid
- X) Collisions of fast moving atoms and molecules of the fluid
- Y) Strong nuclear force among nucleons
- Z) Weak forces among particles

ANSWER: X) COLLISIONS OF FAST MOVING ATOMS AND MOLECULES OF THE FLUID

BONUS

17) PHYSICS *Short Answer* A projectile is launched with a speed of 10 meters per second from the top of a 30 meter tall cliff at an angle of 30° above the horizontal. Assuming that g is 10 meters per second squared, how many seconds after launch will it take this particle to strike the ground at the bottom of the cliff?

ANSWER: 3

TOSS-UP

18) BIOLOGY *Short Answer* In what taxonomic phylum [**FY-luhm**] can you find an indeterminate species in the genus *Marchantia* [**mar-CHANT-ee-uh**]?

ANSWER: HEPATOPHYTA

BONUS

18) BIOLOGY *Short Answer* For a DNA template that reads 3' [**3 prime**] TAC AAA ATC 5' [**5 prime**], give the sequence of the RNA transcribed from it with appropriate polarity.

ANSWER: 5' AUG UUU UAG 3'

TOSS-UP

19) CHEMISTRY *Multiple Choice* Which of the following gases would deviate most from ideal gas behavior?

- W) Helium
- X) Hydrogen
- Y) Oxygen
- Z) Neon

ANSWER: Y) OXYGEN

BONUS

19) CHEMISTRY *Short Answer* How many different structural isomers are there for heptane?

ANSWER: NINE

TOSS-UP

20) MATH *Multiple Choice* What is $\frac{d}{dx} \int_4^x t^2 dt$ [*the derivative with respect to x of the integral from 4 to x of t squared dt*]?

- W) x^2
- X) $(1/3)x^3$
- Y) $(64/3)x$
- Z) $16x^2$

ANSWER: W) x^2

BONUS

20) MATH *Short Answer* What are the vertical and horizontal asymptotes, respectively, of $f(x) = (x^2 - \sqrt{3}) / (x^2 - 2x - 15)$ [*f of x equals the fraction with numerator x squared minus the square root of 3 and denominator x squared minus 2x minus 15*]?

ANSWER: VERTICAL: $x = -3, x = 5$; HORIZONTAL: $y = 1$

TOSS-UP

21) BIOLOGY *Multiple Choice* Which of the following anatomical adjectives is NOT correctly described?

- W) Celiac-abdominal
- X) Anterior-front end
- Y) Rostral-near the tail
- Z) Pedal-relating to the foot

ANSWER: Y) ROSTRAL-NEAR THE TAIL

BONUS

21) BIOLOGY *Short Answer* During the early stages of the Human Genome Project, fragments of human DNA were placed into vectors called yeast artificial chromosomes (YACs). What replication enzyme would be needed in the test tube to connect the two DNA fragments together, creating recombinant DNA?

ANSWER: LIGASE (ACCEPT: DNA LIGASE)

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Which of the following desert landforms is NOT formed through the process of abrasion?

- W) Yardang
- X) Wind bridge
- Y) Desert pavement
- Z) Inselberg

ANSWER: Y) DESERT PAVEMENT

BONUS

22) EARTH AND SPACE *Multiple Choice* Which of the following types of terrace is carved into bedrock?

- W) Fill
- X) Strath
- Y) Alluvium [*uh-LOO-vee-uhm*]
- Z) Accretion

ANSWER: X) STRATH

TOSS-UP

23) PHYSICS *Multiple Choice* A proton initially at rest is accelerated through a potential difference of 1 megavolt. What is its final kinetic energy in electronvolts?

- W) 10^3
- X) 1.6×10^6
- Y) 10^6
- Z) 1.6×10^6

ANSWER: Y) 10^6

BONUS

23) PHYSICS *Short Answer* A 2 kilogram ball experiences a force according to the relation $F = 6t^2$, where F is the force in newtons and t is the time in seconds. Assuming that the ball started from rest, how fast in meters per second is the ball moving after experiencing this force for 5 seconds?

ANSWER: 125

TOSS-UP

24) ENERGY *Multiple Choice* What is the major potential benefit of electric propulsion systems for the NASA space program?

- W) They are lighter than traditional fuels
- X) They are less toxic than traditional fuels
- Y) They contribute to an artificial gravity environment
- Z) They require less research and development

ANSWER: W) THEY ARE LIGHTER THAN TRADITIONAL FUELS

BONUS

24) ENERGY *Multiple Choice* Which of the following advantages is offered by mid- and deep-ocean sequestration that is not possible at shallower depths?

- W) Faster mineralization of carbon dioxide
- X) Easier injection of carbon dioxide
- Y) Buoyant carbon dioxide hydrates
- Z) Longer residence time

ANSWER: Z) LONGER RESIDENCE TIME

TOSS-UP

25) BIOLOGY *Multiple Choice* Which of the following pairs includes a toothed whale and a baleen whale?

- W) Bowhead whale and blue whale
- X) Grey whale and beluga whale
- Y) Sperm whale and narwhal
- Z) Northern right whale and minke

ANSWER: X) GREY WHALE AND BELUGA WHALE

BONUS

25) BIOLOGY *Multiple Choice* At a 4th of July picnic, Uncle Vernon was munching down on his ear of yellow corn when he exclaimed, "Why do some of these corn kernels have purple spots? Is the corn toxic?" You quickly explain that the corn is not toxic and that the spots were caused by what?

- W) Transcription start variation
- X) Transposition of a jumping gene
- Y) Random X-inactivation
- Z) Genetic modifications

ANSWER: X) TRANSPOSITION OF A JUMPING GENE