

TOSS-UP

1. Chemistry *Multiple Choice* Which of the following elements burns green in a flame test?

- W) Barium
- X) Strontium
- Y) Sodium
- Z) Lithium

ANSWER: W) BARIUM [YL]

BONUS

1. Chemistry *Multiple Choice* Which of the following orbitals can NOT combine with a p orbital to form a π bond?

- W) s
- X) p
- Y) d
- Z) f

ANSWER: W) S [YL]

TOSS-UP

2. Math *Multiple Choice* What is the equation of the line tangent to the graph of $y = x^4$ at $(1, 1)$?

- W) $y = -4x + 5$
- X) $y = x$
- Y) $y = 5x - 4$
- Z) $y = 4x - 3$

ANSWER: Z) $y = 4x - 3$ [CW]

BONUS

2. Math *Short Answer* Evan and Yunyi are running a race on a 10 mile track. If Yunyi starts 4 miles ahead of Evan and Yunyi runs at 15 mph, how fast must Evan run, in mph, to catch Yunyi before Yunyi finishes the race?

ANSWER: 25 [CW]

TOSS-UP

3. Earth and Space *Short Answer* What is the term given to small convective cells found on the solar photosphere?

ANSWER: GRANULES [SC]

BONUS

3. Earth and Space *Multiple Choice* Which of the following is FALSE of small solar system body contact binaries?

- W) Contact binary lobes often have distinct compositions
- X) Contact binaries can be separated by rapid rotation
- Y) Contact binaries often show signs of violent impact
- Z) Contact binaries are often rubble piles

ANSWER: Y) CONTACT BINARIES OFTEN SHOW SIGNS OF VIOLENT IMPACT [SC]

TOSS-UP

4. Biology *Multiple Choice* Michelle's cat recently spilled a tank of petroleum in her backyard pond, so she adds the bacteria *P. putida* (*Poo-tee-duh*) to degrade the oil. This is an example of which of the following?

- W) Biomanipulation
- X) Biosparging
- Y) Bioaugmentation
- Z) Bioremediation

ANSWER: Z) BIOREMEDIATION [KW]

BONUS

4. Biology *Multiple Choice* Which of the following statements comparing muscarinic (*muh-skuh-RI-nic*) and nicotinic (*nic-o-TIN-ic*) receptors is NOT true:

- W) Muscarinic receptors are metabotropic (*met-AB-o-tro-pic*), nicotinic receptors are ionotropic (*i-AWN-o-tro-pic*)
- X) Muscarinic receptors innervate smooth muscle, nicotinic receptors innervate skeletal muscle
- Y) Muscarinic receptors are inhibitory, nicotinic receptors are excitatory
- Z) Muscarinic receptors respond to epinephrine, nicotinic receptors respond to acetylcholine

ANSWER: Z) MUSCARINIC RECEPTORS RESPOND TO EPINEPHRINE, NICOTINIC RECEPTORS RESPOND TO ACETYLCHOLINE [KD]

TOSS-UP

5. Physics *Short Answer* An Atwood machine consists of a massless rope connecting a 5 kg mass to a 7 kilogram mass, hung over a massless pulley. What is the magnitude of the acceleration of the masses, in terms of the gravitational acceleration, g?

ANSWER: $g/6$ [**SC**]

BONUS

5. Physics *Short Answer* Caleb has been launched toward the Sun at a speed of 0.96 c. Because of his speed, all of the light from the Sun is blueshifted from his perspective. Compared to a stationary observer at the same position, how many times greater is the solar flux Caleb experiences?

ANSWER: 7 [**SC**]

TOSS-UP

6. Chemistry *Short Answer* What is the name of microporous aluminosilicate minerals that are often used as molecular sieves?

ANSWER: ZEOLITES [**YL**]

BONUS

6. Chemistry *Short Answer* Order the following four diatomic species in terms of increasing bond dissociation enthalpy:

- 1) O_2
- 2) O_2^+
- 3) O_2^-
- 4) O_2^{2-} .

ANSWER: 4, 3, 1, 2 [**YL**]

TOSS-UP

7. Math *Short Answer* Kian is buying pizza. A 5 inch pizza costs him 100 dollars. How much should a 12 inch pizza cost to have the same area per dollar value?

ANSWER: 576 [**EZ**]

BONUS

7. Math *Short Answer* What x-values would make the 2x2 matrix with first row ($x-5, 5$) and second row ($2, x-8$) singular?

ANSWER: 3, 10 [CW]

TOSS-UP

8. Earth and Space *Multiple Choice* Which of the following glacial features is made of till rather than stratified drift?

- W) Ground moraine
- X) Esker
- Y) Kame
- Z) Valley train

ANSWER: W) GROUND MORAINES [KW]

BONUS

8. Earth and Space *Short Answer* Arnav is observing a star with the radial velocity method, and suspects that the oscillations he sees may be due to more than one exoplanet. If this were true, it would be possible to decompose the motion of the star into components due to each individual exoplanet. What technique should Arnav use to verify if this is the case?

ANSWER: FOURIER ANALYSIS [SC]

TOSS-UP

9. Biology *Short Answer* Identify all of the following 4 ions that are likely to be lost in the soil by leaching:

- 1) Nitrate
- 2) Magnesium
- 3) Sulfate
- 4) Potassium

ANSWER: 1 AND 3 [KD]

BONUS

9. Biology *Multiple Choice* An overdose in which of the following vitamins would be the most difficult for the body to get rid of in the urine?

- W) Riboflavin
- X) Tocopherol
- Y) Ascorbic Acid
- Z) Pantothenic Acid

ANSWER: X) TOCOPHEROL [KD]

TOSS-UP

10. Physics *Multiple Choice* Which of these circuit components, when idealized, has nonzero resistance?

- W) Battery
- X) Voltmeter
- Y) Charged capacitor
- Z) Inductor

ANSWER: X) VOLTMETER [SC]

BONUS

10. Physics *Short Answer* Identify all of the following 3 quantities that cannot be stored in electrostatic fields:

- 1) Energy
- 2) Momentum
- 3) Angular momentum

ANSWER: 3 ONLY [SC]

TOSS-UP

11. Chemistry *Multiple Choice* The Aufbau Principle states that in neutral ground-state atoms, electrons are filled in increasing order of subshell energy. Which of the following ground-state elements is an exception to the Aufbau Principle?

- W) Chromium
- X) Iron
- Y) Zinc
- Z) Nitrogen

ANSWER: W) CHROMIUM [W: YL, E: ; C EDE]

BONUS

11. Chemistry *Short Answer* Identify all of the following three thermodynamic processes for which the enthalpy change is greater than the change in internal energy:

- 1) Isobaric expansion
- 2) Isothermal expansion
- 3) Adiabatic expansion

ANSWER: 1 ONLY [YL]

TOSS-UP

12. Math *Multiple Choice* What kind of graph is defined by the parametric equations $x = \sin^2(t)$ and $y = \cos^2(t)$?

- W) Line
- X) Circle
- Y) Ellipse
- Z) Hyperbola

ANSWER: W) LINE [EZ]

BONUS

12. Math *Short Answer* Kian has 8 dollars. Every day, his money has an equal chance of doubling and halving. What is the expected value of how much money he has after 2 days?

ANSWER: 25/2 (ACCEPT: 12.5) [EZ]

TOSS-UP

13. Earth and Space *Short Answer* A palimpsest forms on a moon or planetary body's surface when many of what kind of feature overlap?

ANSWER: CRATER [SC]

BONUS

13. Earth and Space *Short Answer* Identify all of the following 3 coasts of the United States that are correctly matched with the main kind of tide they experience:

- 1) Pacific, semidiurnal

- 2) Atlantic, mixed
- 3) Gulf of Mexico, diurnal.

ANSWER: 3 ONLY [SC]

TOSS-UP

14. Biology *Multiple Choice* Which of the following embryonic structures is NOT derived from mesoderm?

- W) Notochord
- X) Somites
- Y) Coelom
- Z) Neural Tube

ANSWER: Z) NEURAL TUBE [KD]

BONUS

14. Biology *Short Answer* Identify all of the following 3 statements that correctly describe what occurs when Parathyroid Hormone concentration is increased:

- 1) Stimulation of osteoclasts
- 2) Stimulation of osteoblasts
- 3) Reabsorption of phosphate in the kidney

ANSWER: 1 ONLY [KD]

TOSS-UP

15. Physics *Short Answer* The Dulong-Petit model of solid heat capacity states that the heat capacity is inversely proportional to molar mass. This model can be derived by what statistical mechanics theorem that describes the thermal energy per degree of freedom?

ANSWER: EQUIPARTITION THEOREM [YL]

BONUS

15. Physics *Short Answer* A 50 kg ball is given a very large charge of 3 C and balanced above a fixed point charge of 6 C above the ground. What is the distance it floats above the ground, in meters and in scientific notation, to one significant figure?

ANSWER: 2×10^4 [SC]

TOSS-UP

16. Chemistry *Short Answer* An organic molecule may have no chiral centers but still be chiral due to hindered single-bond rotation. What form of isomerism is this?

ANSWER: ATROPISOMERISM [YL]

BONUS

16. Chemistry *Multiple Choice* Solution A consists of 0.1 molar acetic acid, which has a pKa of 4.8. Solution B consists of 1 molar acetic acid. Which of the following best compares the pH and the percent ionization of the two solutions, respectively?

- W) Solution A has higher pH and solution A has higher percent ionization
- X) Solution A has higher pH and solution B has higher percent ionization
- Y) Solution B has higher pH and solution A has higher percent ionization
- Z) Solution B has higher pH and solution B has higher percent ionization

ANSWER: W) Solution A has higher pH and solution A has higher percent ionization [YL]

TOSS-UP

17. Math *Multiple Choice* What kind of shape is represented by the equation $r = 4 - 3\cos\theta$?

- W) Circle
- X) Dimpled limacon (LEE-MA-SON)
- Y) Cardioid
- Z) Looped limacon

ANSWER: X) DIMPLED LIMAON [EZ]

BONUS

17. Math *Short Answer* A sandwich shop sells sandwiches in lengths of 6 and 16 inches. If Kian wants to get exactly 20 feet of sandwich, in how many ways can he do it?

ANSWER: 6 [EZ]

TOSS-UP

18. Earth and Space *Short Answer* Order the following three variable star classes in order of increasing period:

- 1) Mira
- 2) RR Lyrae
- 3) Classical Cepheid

ANSWER: 2, 3, 1 [SC]

BONUS

18. Earth and Space *Short Answer* Which of the following properties can be used to identify an interloper in a family of small solar system bodies?

- 1) Inclination
- 2) Spectra
- 3) Eccentricity

ANSWER: 2 [SC]

TOSS-UP

19. Biology *Short Answer* After one round of replication in Meselson and Stahl's experiment, all of the daughter DNA was half-heavy. Identify all of the following 3 models of DNA replication that are consistent with this first round of data:

- 1) Conservative
- 2) Semiconservative
- 3) Dispersive

ANSWER: 2 AND 3 [KD]

BONUS

19. Biology *Short Answer* A fungus that forms ectomycorrhizal (*EC-to-my-COR-riz-uhl*) relationships would most likely be a part of what phylum?

ANSWER: BASIDIOMYCOTA [KD]

TOSS-UP

20. Physics *Short Answer* At low temperatures, quarks can only be found as part of composite particles, and cannot be found individually. What is the term for this phenomenon?

ANSWER: COLOR CONFINEMENT [SC]

BONUS

20. Physics *Short Answer* In a region with a uniform magnetic field, a proton is moving in a circular magnetic orbit of radius r with some period T . If an alpha particle is moving in the same magnetic field in a circle of radius $2r$, what is its period in terms of T ?

ANSWER: $T/2$ [SC]

TOSS-UP

21. Chemistry *Multiple Choice* Help! Stephen just ate a vial of silver chloride. Which of the following reagents can be used to dissolve silver chloride in an aqueous solution?

- W) NH_3
- X) NaCl
- Y) H_2SO_4
- Z) NaOH

ANSWER: W) NH_3 [YL]

BONUS

21. Chemistry *Multiple Choice* What does the pre-exponential factor A in the Arrhenius equation most closely represent?

- W) The frequency of successful collisions
- X) The kinetic energy of particles that collide
- Y) The activation energy of the reaction
- Z) The stability of the activated complex

ANSWER: W) THE FREQUENCY OF SUCCESSFUL COLLISIONS [AY]

TOSS-UP

22. Math *Short Answer* A rectangle with area 420 has one side of length 20. What is the length of the rectangle's diagonal?

ANSWER: 29 [EZ]

BONUS

22. Math *Short Answer* Stephen loves playing Science Bowl, but has an unfortunate habit of negging a lot. For every question, Stephen has a 60% chance of getting it right, earning 4 points and a 40% chance of negging, losing 4 points. If Stephen gets the question right, he will receive a BONUS question worth 10 points, which he answers correctly 60% of the time. What is the expected value of the number of points Stephen will earn in a 10 question set?

ANSWER: 44 [CW]

TOSS-UP

23. Earth and Space *Multiple Choice* Geostrophic flow occurs when what two forces are balanced?

- W) Pressure differential and centrifugal
- X) Centrifugal and gravitational
- Y) Gravitational and coriolis
- Z) Coriolis and pressure differential

ANSWER: Z) CORIOLIS AND PRESSURE DIFFERENTIAL [SC]

BONUS

23. Earth and Space *Short Answer* Order the following 3 rock beds from bottom to top as they would be found on a shoreline following transgression:

- 1) Siltstone
- 2) Sandstone
- 3) Shale.

ANSWER: 2, 1, 3 [SC]

TOSS-UP

24. Biology *Multiple Choice* A drug that prevents ribosomal binding to the Kozak sequence would prevent which of the following processes?

- W) Transcription in Prokaryotes
- X) Transcription in Eukaryotes
- Y) Translation in Prokaryotes
- Z) Translation in Eukaryotes

ANSWER: Z) TRANSLATION IN EUKARYOTES [KD]

BONUS

24. Biology *Short Answer* Benzodiazepines, which are often prescribed to treat anxiety and promote sleep, act by increasing the permeability to chloride ions in receptors for what primary inhibitory neurotransmitter?

ANSWER: GABA (ACCEPT: GAMMA-AMINOBUTYRIC ACID) [KD]

TOSS-UP

25. Physics *Short Answer* A charge is placed at the origin and a square aligned with the x-y plane is then centered at the point (0, 0, 2). If the square is instead moved to (0, 0, 3) in the same orientation, by what factor is the flux through it changed?

ANSWER: 4/9 [SC]

BONUS

25. Physics *Short Answer* A is on a train moving at $3/5 c$, while B is spying on them from another train moving at $4/5 c$ in the same direction. A spends two minutes knitting a hat in their own frame — in seconds, how long do they take in B's frame?

ANSWER: 130 [SC]