

Tossup

1) *Earth and Space - Multiple choice:* Which of the following minerals is found in the largest quantities at the bottom of the Mediterranean sea?

- W) Glaucophane [glock-o-fain]
- X) Quartz
- Y) Gypsum
- Z) Halite

ANSWER: Y) Gypsum

Bonus

1) *Earth and Space – Multiple Choice:* Identify all of the following 3 major ocean currents that are western boundary currents:

- I) Gulf Stream
- II) Kuroshio Current
- III) Agulhas [ag-ool-has] Current

ANSWER: ALL

Tossup

2) *Chemistry – Multiple Choice:* Two unknown solutions are mixed together. The resulting solution changes from a vibrant magenta to a light pink. Which of the following processes best aligns with the observed color change?

- W) Oxidation of Fe^{2+} to Fe^{3+}
- X) Reduction of Ti^{2+} to Ti
- Y) Oxidation of Mn^{2+} to Mn^{4+}
- Z) Reduction of Mn^{7+} to Mn^{2+}

ANSWER: Z) Reduction of Mn^{7+} to Mn^{2+}

Bonus

2) *Chemistry – Multiple Choice:* In a thin layer chromatography setup, the R_f [READ: R f] values of compounds A and B are measured. Which of the following conditions would lead to the compounds being farthest from each other on the plate when the experiment is completed?

- W) R_f of A is 0.2, R_f of B is 0.2
- X) R_f of A is 0.2, R_f of B is 0.3
- Y) R_f of A is 0.2, R_f of B is 0.5
- Z) R_f of A is 0.2, R_f of B is 0.7

ANSWER: Z) R_f of A is 0.2, R_f of B is 0.7

Tossup

3) *Energy – Short Answer:* Researchers at SLAC National Accelerator Facility are studying the ways the subatomic particles travel through space and through the Earth's atmosphere. What effect best explains why muons are able to reach the surface of the earth, despite their lifetime being less than the time it takes for them to travel through the atmosphere?

ANSWER: Length contraction OR time dilation

Bonus

3) *Energy – Short Answer:* Researchers at Oak Ridge National Laboratory are studying how cells get their supply of glucose. What is the name of the channels that allow for glucose to travel across the cell membrane?

ANSWER: GLUT transporters

Tossup

4) *Physics – Short Answer:* Andrew quickly constructs a makeshift parallel-plate capacitor using olive oil as a dielectric, which has a dielectric constant of 3. He realizes that there are many ways to improve it to have even more capacitance, so he builds another capacitor with 4 times the plate area using deionized water as a dielectric, which has a dielectric constant of 30. What is the ratio of the new capacitance to the old capacitance?

ANSWER: 40

Bonus

4) *Physics – Short Answer:* Rishabh has a mass of 100 kilograms and is standing still. He is hit inelastically by a truck with mass 1000 kilograms traveling at 10 meters per second. To the nearest tenth of a meter per second, what is the speed that Rishabh flies off at?

ANSWER: 9.1 m/s

Tossup

5) *Biology – Multiple Choice:* According to the ABC hypothesis, a plant with a non-functioning A gene will develop which of the following floral patterns?

- W) sepal-petal-petal-sepal
- X) carpel-carpel-stamen-stamen
- Y) carpel-stamen-stamen-carpel
- Z) petal-carpel-carpel-petal

ANSWER: Y) carpel-stamen-stamen-carpel

Bonus

5) *Biology – Short Answer:* Order the following 4 valves of the heart in the order that blood goes through them after entering the pulmonary vein:

- 1) Aortic Valve
- 2) Tricuspid Valve
- 3) Mitral Valve
- 4) Pulmonary Valve

ANSWER: 3, 1, 2, 4

Tossup

6) *Earth and Space– Short Answer:* In what type of meteorite can you find elongated crystals of metal?

ANSWER: Iron meteorite (Accept: Iron)

Bonus

6) *Earth and Space– Short Answer:* What two metals are widmanstätten [**wit-man-stat-en**] patterns primarily composed of?

ANSWER: Iron and Nickel

Tossup

7) *Physics – Short Answer:* Consider a PV graph with volume in cubic meters on the X axis and pressure in pascals on the Y axis. If a process on this graph begins at (4, 500) and ends at (2, 2000) while moving along a straight line path, what is the work in Joules done by the system during this process?

ANSWER: -2500 J

Bonus

7) *Physics – Short Answer:* Identify all of the following 3 quantities that have a positive value during isothermal expansion:

- I) Work done by the system
- II) Change in internal energy
- III) Heat added to the system

ANSWER: I and III

Tossup

8) *Math – Short Answer:* 7 positive consecutive integers starting with A have average B. In terms of A, what is the average of 9 consecutive integers that start with B?

ANSWER: $A + 7$

Bonus

8) *Math – Multiple Choice:* What is the value of the fraction with numerator 2 to the power of 1001 plus 2 to the power of 1004 and denominator 2 to the power of 1002 minus 2 to the power of 1004?

ANSWER: $-3/2$

Tossup

9) *Chemistry – Short Answer:* What is the hybridization of the center metal atom in a complex with a square planar geometry?

ANSWER: dsp^2

Bonus

9) *Chemistry – Short Answer:* Which quantum number describes the orientation of subshells within three-dimensional space?

ANSWER: Magnetic quantum number (ACCEPT: ml, m sub l)

Tossup

10) *Physics – Short Answer:* Two metal plates are placed in a constant magnetic field. Plate A has an area of 1 square meter and is oriented normal to the magnetic field lines, while Plate B has an area of 3 square meters and is oriented such that its normal is 30 degrees from the magnetic field lines. What is the ratio of flux through Plate B to the flux through Plate A?

ANSWER: $3\sqrt{3}/2$ [**3 square root of 3 over 2**]

Bonus

10) *Physics – Multiple Choice:* Three solid spherical balls, A, B, and C, are placed on an inclined plane and released at the same time. Ball A is made of steel and has a radius of R, Ball B is made of wood and has a radius of 2R, and Ball C is made of tungsten and has a radius of $\frac{1}{2}R$. Which ball would reach the bottom of the plane first?

W) Ball A

X) Ball B

Y) Ball C

Z) All three would reach the bottom at the same time

ANSWER: Z) All three would reach the bottom at the same time

Tossup

11) *Biology – Multiple Choice*: On planet X, eagles have evolved to grow long beaks in adulthood. Eagles on planet Y have also evolved to have long beaks, although they are not evolutionarily related to the eagles on planet X. Which of the following best describes the taxonomic group consisting of X and Y

- W) Monophyletic [**mono-fy-let-ic**]
- X) Polyphyletic
- Y) Paraphyletic
- Z) Periphyletic

ANSWER: X) Polyphyletic

Bonus

11) *Biology – Short Answer*: What is the name for the sites of homologous recombination between homologous chromosomes during crossing over?

ANSWER: Chiasmata

Tossup

12) *Energy – Short Answer*: Researchers at Idaho National Lab are studying the behavior of ideal gases in various environments, which can be mathematically expressed with the ideal gas law. Identify all of the following 4 relationships that are shown through the ideal gas law:

- I) Avogadro's Law
- II) Boyle's Law
- III) Charles's Law
- IV) Gay-Lussac's Law [**gay-loo-SACK**]

ANSWER: ALL

Bonus

12) *Energy – Short Answer*: Scientists at Argonne National Laboratory are studying microtubular cytoskeletal elements. Identify all of the following 4 structures that follow a “9+0” structure

- I) Basal body
- II) Flagella
- III) Motile cilia
- IV) Non-motile cilia

ANSWER: I, IV

Tossup

13) *Math – Short Answer:* Andrew is practicing his free throws at the local park basketball court. If Andrew's free throw average is 0.4, what is the average number of throws it will take for him to make one?

ANSWER: 2.5

Bonus

13) *Math – Short Answer:* What is the remainder when $\frac{1}{2}x^4 + 2x^3 - x^2 + 4x + 1$ is divided by $(x - 2)$?

ANSWER: 29

Tossup

14) *Earth and Space – Multiple Choice:* At a certain time, in an area with semidiurnal **[semi-di-urn-al]** tides, high tide is at high noon. Identify all of the following 4 phases which could be the current phase of the moon in this area at this time?

- I) New Moon
- II) First Quarter
- III) Waxing gibbous
- IV) Third Quarter

ANSWER: I only

Bonus

14) *Earth and Space– Short Answer:* Identify all of the following 4 bodies that are Kuiper **[ky-per]** Belt Objects:

- I) Ceres
- II) Pluto
- III) Eris
- IV) Vesta

ANSWER: II, III

Tossup

15) *Energy – Short Answer:* After a very large conference, janitors at the Department of Energy are stacking chairs, where the stacks must have less than 30 chairs. After they made 95 equal stacks using all the chairs, the janitors realized that they could have saved a lot of space if they made 19 equal stacks. Assuming that there were more than 400 but less than 700 chairs used for this conference, how many chairs were used?

ANSWER: 475

Bonus

15) *Energy – Short Answer:* Researchers at the Lawrence Livermore National Lab are using the velocity interferometer system to measure the shocked states found in shock compression experiments. Which of the following principles does the Velocity interferometer system use to measure velocimetry data?

- W) Doppler Shift
- X) Huygen's Principle
- Y) Chromatic Aberration
- Z) Optical Depth

ANSWER: W) Doppler Shift

Tossup

16) *Biology – Short Answer:* Identify all of the following 4 hormones that suppress the feeling of hunger:

- I) Leptin
- II) Ghrelin [**grel-in**]
- III) Insulin
- IV) PYY

ANSWER: I, III, IV

Bonus

16) *Biology – Short Answer:* What amino acid does the body use to store ammonia?

ANSWER: Glutamine

Tossup

17) *Physics – Multiple Choice*: Which of the following quantities is not matched with the correct units?

- W) Impulse, Newton-seconds
- X) Energy, Newton-meters
- Y) Pressure, Newtons per meter
- Z) Weight, Newtons

ANSWER: Y) Pressure, Newtons per meter

Bonus

17) *Physics – Short Answer*: Identify all of the following 3 situations that can be reasonably approximated as a harmonic oscillator:

- I) A stick swinging around a pivot
- II) A bobber floating on water
- III) A frictionless piston connected to a cylinder of ideal gas

ANSWER: ALL

Tossup

18) *Chemistry – Short Answer*: What is the degree of unsaturation of the compound $C_{10}H_{20}O$?

ANSWER: 1

Bonus

18) *Chemistry – Short Answer*: Rishabh, trying to imitate his favorite chemists, has defined a new thermodynamic variable that he calls Bedidha Free Energy, represented by B. The Bedidha Free Energy for a certain process is defined as the sum of the system's internal energy and the heat added during that process. Identify all of the following 3 properties that apply to Bedidha Free Energy:

- I) It is a state variable
- II) It is conserved throughout a cycle
- III) It is equal to the enthalpy minus the Gibbs Free energy

ANSWER: None

Tossup

19) *Math – Short Answer:* Identify all of the following four polyhedra that can tile all of 3d space without gaps:

- I) Tetrahedron
- II) Hexagonal prism
- III) Scalene triangular prism
- IV) Skew rectangular prism

ANSWER: II, III, and IV

Bonus

19) *Math – Short Answer:* A function $f(x)$ has derivative given by $dy/dx = 2 - x$, and $f(1) = 0$. What is the limit as x approaches 1 of $f(x) / (x^3 - 1)$ [**READ: f of x divided by open parenthesis x cubed minus 1 closed parenthesis**]?

ANSWER: 1/3

Tossup

20) *Earth and Space – Short Answer:* What mineral would first precipitate out of ultramafic magma at ambient pressures?

ANSWER: Olivine

Bonus

20) *Earth and Space – Short Answer:* Identify all of the following 4 formations that can only form with the occurrence of multiple glaciers in close proximity:

- I) Arete [**air-eet**]
- II) Horn
- III) Esker
- IV) Ruche Moutonnee [**roo-sh moo-ton-ay**]

ANSWER: I, II

Tossup

21) *Biology – Short Answer:* What type of cells in the eyes are responsible for sensing information about colors?

ANSWER: Cones

Bonus

21) *Biology – Multiple Choice:* Which of the following is the best example of antibiosis?

- W) Plant secretions preventing insect growth
- X) Two finches competing for food
- Y) A tapeworm stealing nutrients from a host
- Z) A lion hunting a zebra

ANSWER: W) Plant secretions preventing insect growth

Tossup

22) *Math – Short Answer:* What is the product of all of the 5th roots of $1 + \sqrt{3}i$?

ANSWER: $1 + \sqrt{3}i$

Bonus

22) *Math – Short Answer:* Consider two positive integers x and y . If x is divisible by 2 and y is divisible by 4, identify all of the following 3 statements that must be true:

- I) xy is divisible by 8
- II) y is divisible by x
- III) x is divisible by y

ANSWER: I only

Tossup

23) *Chemistry – Short Answer*: What law states that if a reaction is carried out in multiple steps, the enthalpy change for the overall reaction can be expressed as a sum of the enthalpy changes for each of the individual steps?

ANSWER: Hess's Law

Bonus

23) *Chemistry – Multiple Choice*: What is the oxidation state of the central atom in the anion of the compound NaH_2PO_2 ?

W) +3

X) -1

Y) +1

Z) -2

Answer: Y) +1