Tossup

1) *Math – Short Answer:* What is the trace of the row reduced echelon form of the 4 by 4 matrix with **[READ CAREFULLY]** first row [-2, -3, 4, 1], second row [2, 4, 1, 2], third row [-3, -3, 1, 4], and fourth row [1, 1, -2, 2]?

ANSWER: 4

Bonus

1) *Math – Multiple Choice:* Which of the following points remains fixed when multiplied by the matrix with first row [3, 1] and second row [2, 2]?

W) (2, -4)
X) (1, 1)
Y) (-1, 3)
Z) (-3, -2)

ANSWER: W) (2, -4)

Tossup

2) *Energy – Short Answer:* Researchers at Lawrence Berkeley National Laboratory are studying charge parity violation via the decay of quarks and leptons. Charge parity violation implies that what other fundamental symmetry is violated?

ANSWER: Time reversal symmetry (DO NOT ACCEPT: time symmetry)

Bonus

2) *Energy – Multiple Choice:* Researchers at the NIH are studying the effects of fluoride poisoning. Which of the following correctly describes the effect of fluoride on the function of the thyroid gland?

W) Fluoride binds to T_3 and T_4 receptors blocking their function
X) Fluoride replaces iodine T_4 inhibiting the production of T_3
Y) Fluoride can act as a substitute for iodine in T_3 and T_4 allowing for greater production of the hormones
Z) Fluoride binds to receptors on the thyroid gland inhibiting its function

ANSWER: W) Fluoride binds to T_3 and T_4 receptors blocking their function

Tossup

3) *Chemistry – Short Answer:* Identify all of the following 3 compounds that are conjugated but not aromatic?

I) Buckminsterfullerene
II) Naphthalene
III) Annulene

ANSWER: I and III

Bonus

3) *Chemistry – Short Answer:* Oxidized buckminsterfullerene has the formula $C_{60}O$ and takes the form of a ketone. How many different structural isomers of $C_{60}O$ ketones are there?

ANSWER: 1

Tossup

4) *Earth and Space – Multiple Choice:* White lines of algae have formed on the surface of a lake in the Northern hemisphere. Which of the following correctly describes the net flow of wind and water in this system?

W) Wind blows parallel to the lines, and water flows due right of the wind forming an Ekman spiral
X) Wind blows parallel to the lines and water flows due left of the wind forming an Ekman spiral
Y) Wind blows perpendicular to the lines and water flows due right of the wind in a helical pattern
Z) Wind blows parallel to the lines and water flows parallel to the wind in a helical pattern

ANSWER: Z) Wind blows parallel to the lines and water flows parallel to the wind in a helical pattern

Bonus

4) *Earth and Space – Multiple Choice:* The Rossby Radius of Deformation is defined to be the length in which the forces of rotation are as significant as buoyancy or gravity waves. Which of the following has the lowest effect on the Rossby Radius of Deformation for bodies of water?

W) Depth
X) Latitude
Y) Stratification
Z) Tidal Forces

ANSWER: Z) Tidal Forces

Tossup

5) *Biology – Short Answer:* Lipid rafts are most abundant with that type of membrane lipid?

ANSWER: Sphingolipids

Bonus

5) *Biology – Short Answer:* There is a moat full of alligators that surrounds Enloe. The alligators at the front of the school formed the original species that was introduced. Over time they spread down the flanks, each side of the school evolving separately. The alligators were able to mate with the species directly next to them, except for at the end where the 2 flanks met. What is the name of such a group of populations?

Answer: Ring Species

Tossup

6) *Physics – Short Answer:* Assuming constant volume, what thermodynamic state function is equal to the partial derivative of internal energy with respect to entropy?

ANSWER: Temperature

Tossup

6) *Physics – Multiple Choice:* Two rods with the same length but different thermal conductivities are put together to form one longer rod. The thermal conductivity of the rod on the left is 12, and the thermal conductivity of the one on the right is 8. The temperature of the left end of the two rods put together is held at a constant 20K, and the temperature of the right side is held at a constant 40K. The two rods put together reach a steady state. In Kelvin, what is the temperature at the point where the two rods meet?

W) 24
X) 26
Y) 28
Z) 30

ANSWER: Y) 28

Tossup

7) *Energy – Short Answer:* Scientists at Princeton Plasma Physics Laboratory are studying physical models of magnetically confined plasmas. These plasmas are one of many fluids that conduct electricity. What is the term for the study of these fluids?

ANSWER: Magnetohydrodynamics [Accept: MHD, Magneto-fluid dynamics, hydromagnetics]

Bonus

7) Energy – Short Answer: Researchers at Lawrence Berkeley national laboratory are studying fatty acid synthesis. Acetyl COA(Coenzyme A) carboxylase is an important enzyme in this process, making Malonyl COA, which is a building block for fatty acid. Identify all of the following 4 molecules that cause a negative feedback loop with Acetyl COA Carboxylase:

I) Norepinephrine
II) Epinephrine
III) Citrate
IV) Long Fatty Acid Chains

ANSWER: I, II, IV

Tossup

8) *Biology – Multiple Choice:* Which of the following correctly matches the effect of uncompetitive inhibition on the Lineweaver Burk plot?

W) K_{max} reduced, V_{max} increased
X) K_{max} increased , V_{max} reduced
Y) K_{max} unaffected, V_{max} increased
Z) K_{max} reduced, V_{max} reduced

ANSWER: Z

Tossup

8) *Biology – Multiple Choice:* Which of the following protists share the most features with modern day plants?

W) Chlorophytes
X) Choanoflagellates
Y) Diplomonads
Z) Charophytes

ANSWER: Z

Tossup

9) *Chemistry – Multiple Choice:* Which of the following is not a reason that TMS is used as a standard in H1 NMR?

W) It is soluble in both polar and nonpolar solvents
X) All of it's 12 degenerate protons create a sharp, tall peak
Y) It's proton resonance chemical shift is lower than most compounds
Z) It is inert, and is not likely to react with samples

ANSWER: W) It is soluble in both polar and nonpolar solvents

Bonus

9) *Chemistry – Short Answer:* According to Bent's rule, orbitals associated with the oxygen-hydrogen bond in water molecules have a bond order of sp^x **[READ: sp to the x]**. What is x to the nearest integer?

ANSWER: 4

Tossup

10) *Math – Multiple Choice:* What is the volume of a tetrahedron with side lengths 2, 3, 4, 5, sqrt(13), and sqrt(20).

W) 4
X) 5
Y) 12
Z) 15

ANSWER: W) 4

Bonus

10) *Math – Short Answer:* What is the number of positive integers less than 100 that cannot be expressed as the product of two distinct positive integers greater than 1?

ANSWER: 30

Tossup

11) *Biology – Multiple Choice:* From first to last, order the following 4 structures based on the sequence in which electric signals pass through them during heart activation:

1) Purkinje Fibers
2) Sinoatrial Node
3) Bundle of His
4) Atrioventricular Node

Answer: 2, 4, 3, 1

Bonus

11) *Biology – Short Answer:* When damages in the DNA helix occur in the path of DNA replication, replication proceeds by continuing around the damage through what process?

ANSWER: Translesion Synthesis

Tossup

12) *Earth and Space – Short Answer:* Order the following 4 feldspars from lowest to highest melting point:

1) Anorthite
2) Labradorite
3) Albite
4) Orthoclase

ANSWER: 4, 3, 2, 1

Bonus

12) *Earth and Space – Multiple Choice:* Which of the following best explains the reasoning for the low seismic wave velocities in the Low Velocity Zone?

W) Partial melting in the zone yields a lower bulk modulus.
X) Partial melting in the zone yields a higher bulk modulus
Y) Partial melting in the zone yields a lower density
Z) Partial melting in the zone yields a higher density

ANSWER: W) Partial melting in the zone yields a lower bulk modulus.

Tossup

13) *Math – Multiple Choice:* The Enloe Science Bowl C Team is keeping track of their tossup accuracy rate across the entire season. They note that their accuracy rate was below 75%, but after their game against the Ligon C team, their accuracy rate was above 75%. Was there necessarily a point in the game where their tossup accuracy rate was exactly 75%?

W) Yes
X) No
Y) Depends on how many tossups they get correct
Z) Impossible to determine

ANSWER: W) Yes

Bonus

13) *Math – Short Answer:* Sukrith wants to adopt some bunnies and dogs from his local animal shelter. He wants to choose exactly 2 more bunnies than dogs, and can choose from 6 bunnies and 4 dogs. Assuming that each bunny and dog is unique, how many combinations of animals could he adopt?

ANSWER: 210

Tossup

14) *Chemistry - Multiple Choice:* The conductivity of polysilanes is due to which of the following causes?

W) Pi-delocalization
X) Sigma-delocalization
Y) Presence of an impurity
Z) Proton transfer

ANSWER: X

Bonus

14) *Chemistry – Short Answer:* By the Covalent Bond Classification method, sometimes known as LXZ notation, what is the classification of $[Mn(CO)_6^+]$?

ANSWER: ML6 (Accept 6L, MnL6, answers that mention 6 L classified bonds)

Tossup

15) *Physics – Short answer:* Rishabh is going on a trip in his favorite rocketship which travels at 0.5c relative to the static reference frame. While in his rocket he witnesses Pranav's rocket fly past him traveling in the same direction he is at a speed of 0.5c. In terms of c, what is the speed of Pranav's rocket as observed from the static reference frame?

ANSWER: .8c

Bonus

15) *Physics – Multiple Choice:* The Hall Effect describes a phenomenon where a potential difference is created in a resistor in the presence of an external magnetic and internal electric field. Which of the following statements is true of the Hall effect?

W) The induced electric field is perpendicular to the two other fields
X) It only applies to materials at extremely low temperatures
Y) It is another form of the principle behind the Meissner effect
Z) It is the reason that Cooper pairs form

ANSWER: W) The induced electric field is perpendicular to the two other fields

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Tossup

16) *Energy – Multiple Choice:* In the 1960s, researchers at SLAC National Laboratory ran an experiment using deep inelastic scattering off of individual protons in order to determine which of the following?

W) The value of the elementary charge
X) The existence of the Higgs Boson
Y) The existence of quarks
Z) The exact mass of a proton

ANSWER: Y) The existence of quarks

Bonus

16) *Energy – Multiple Choice:* Researchers at Lawrence Berkeley National Laboratory are studying neural networks, which can be represented in a directed graph. If a directed graph has nodes of A, B, and C and has an adjacency matrix of first row 1 0 1, second row 1 1 0, and third row 0 0 1, how many total possible paths of length 2 end at C?

ANSWER: 4

Tossup

17) *Math – Short Answer:* What is the smallest positive integer greater than 1 that is relatively prime to 2, 20, 202, and 2022?

ANSWER: 7

Bonus

17) *Math – Short Answer:* A right octagonal prism has all sides of length 3. Giving your answer in exact form, what is its volume?

ANSWER: $54+54\sqrt{2}$

Bonus

18) *Earth and Space – Short Answer:* Order the following 4 molecules from greatest to least abundance in the atmosphere of Mars:

1) Nitrogen
2) Carbon Dioxide
3) Oxygen
4) Argon

ANSWER: 2, 4, 1, 3

Tossup

18) *Earth and Space – Short Answer:* Order the following 4 planets in order of increasing density:

1) Jupiter
2) Saturn
3) Uranus
4) Neptune

ANSWER: 2,3,1,4

Tossup

19) *Chemistry – Multiple Choice:* In which of the following compounds is the enol favored in keto-enol tautomerization?

W) Acetaldehyde
X) Propionaldehyde
Y) Butenol
Z) Phenol

ANSWER: Z) Phenol

Bonus

19) *Chemistry – Short Answer:* Identify all of the following 4 compounds that are aromatic:

I) Cyclooctatetraene
II) Pyrrole
III) Tetrahydrofuran
IV) Dioxane

ANSWER: II only

Tossup

20) *Physics – Multiple Choice:* Colin is speeding in his supercar as he approaches a red light. Since he is late to work and does not want to wait for the light to turn green, he accelerates in order to blueshift the light from the stoplight to appear green to him. Assuming that red light has a wavelength of 650 nanometers and green light has a wavelength of 550 nanometers, which of the following speeds is closest to the speed he must travel to make the light appear green?

W) 0.1c
X) 0.2c
Y) 0.3c
Z) 0.4c

ANSWER: X) 0.2c

Bonus

20) *Physics – Short Answer:* If 2 charges of charge q placed 1 meter from each other have a potential energy of 4 J, then to one significant figure, what is the potential energy in Joules of 8 of these charges placed in a cube with a 1 meter side length?

ANSWER: 90

Tossup

21) *Biology – Short Answer:* In Hoogsteen-like base pairing, how many guanines join together to form a single compex?

ANSWER: 4

Bonus

21) *Biology – Multiple Choice:* In paramecium the codons UAA and UGA no longer code for termination. What amino acid do they code for instead. ?

W) Glutamine
X) Glycine
Y) Asparagine
Z) Lysine

ANSWER: W) Glutamine

Tossup

22) *Earth and Space – Short Answer:* What is the name for the present cosmological era in which stars, galaxies, and other celestial bodies contain the most amount of matter and produce the most energy?

ANSWER: Stelliferous Era

Bonus

22) *Earth and Space – Multiple Choice:* The galaxy EGSY8p7 has a redshift of 8.7. Which of the following is closest to its velocity in kilometers per second with respect to the Earth?

W) $2.6 * 10^6$ km/s
X) $6.1 * 10^6$ km/s
Y) $2.6 * 10^9$ km/s
Z) $6.1 * 10^9$ km/s

ANSWER: W

Tossup

23) *Physics – Short Answer:* Many thermodynamic processes can be described easily by identifying quantities that remain constant throughout them, and many of these constant quantities can be written in the form PV^n **[P V to the n]**. Order the following 3 processes from lowest to highest values of constant n:

1) Isothermal
2) Isentropic
3) Isobaric

ANSWER: 3, 1, 2

Bonus

23) *Physics – Short Answer:* Thanush is playing golf with a golf ball of mass 0.05 kg. He hits the ball so that it is launched at a 45 degree angle and travels a distance of 160 meters. The golf club is in contact with the ball for 0.3 seconds. To two significant figures, what is the average force on the ball during the collision (in meters per second)?

ANSWER: 6.7