Tossup

1) *Biology – Short Answer:* What type of chromosomal inversion includes an exchange of regions including the centromere?

ANSWER: Pericentric inversion

Bonus

1) *Biology – Multiple Choice:* In a species of Eldians, the ability to turn into a titan is inherited in an autosomal dominant pattern with allele frequency of 0.9 and penetrance of 80%. Levi is one of the few Eldians who genotypically cannot turn into a titan. If he mates with a random Eldian, what is the probability his child will also be unable to turn into a titan?

W) 0.09
X) 0.18
Y) 0.27
Z) 0.54

ANSWER: Y) 0.27

Tossup

2) *Math – Multiple Choice:* Which of the following pairs of numbers are relatively prime?

W) 162 and 243
X) 165 and 286
Y) 227 and 350
Z) 450 and 502

ANSWER: Y) 227 and 350

Bonus

2) *Math – Short Answer:* How many injective functions f from the set S{1,2,3,4} **[S 1 2 3 4]** to itself exist where no element x in S is mapped to its inverse modulo 5?

ANSWER: 9

Tossup

3) *Physics – Short Answer:* What is the name for the magnetic analog to the electric potential?

ANSWER: Vector potential (ACCEPT: Magnetic vector potential)

Bonus

3) *Physics – Short Answer:* Identify all of the following 4 quantities that are correctly paired with their conjugate quantities:

I) Energy and time
II) Temperature and heat
III) Electric potential and charge density
IV) Gravitational potential and mass density

ANSWER: I, III, and IV

Tossup

4) *Chemistry – Multiple Choice:* Which of the following ions is not matched with a preferential binding crown ether?

W) Lithium, 12 crown 4
X) Sodium, 15 crown 5
Y) Potassium, 16 crown 6
Z) Cesium, 21 crown 7

ANSWER: Y) Potassium, 16 crown 6

Bonus

4) *Chemistry – Short Answer:* In the Lennard-Jones potential equation, intermolecular distance is raised to what power in the leading order term when describing the effects of Pauli repulsion?

ANSWER: -12

Tossup

5) *Energy – Multiple Choice:* Scientists in the USGS are studying the propagation of tsunamis in the Pacific ocean. Given that the Pacific ocean has an average depth of 4 kilometers, to one significant figure and in meters per second, calculate the phase velocity of a tsunami in the center of the Pacific ocean.

ANSWER: 200 m/s

Bonus

5) *Energy – Multiple Choice:* Researchers at Lawrence Berkeley National Laboratory trying to use quantum computing to improve Markov Chain algorithms used in traditional computers. Which of the following properties of a system could not be correctly simulated using a Markov chain?

W) Wave diffraction
X) Relativistic effects
Y) Hysteresis
Z) Black-body emission

ANSWER: Y) Hysteresis

Tossup

6) *Physics – Multiple Choice:* The nearly-free electron model improves on the Sommerfield model by making which of the following assumptions?

W) Electrons follow Fermi-Dirac statistics
X) Electrons are only observable in a finite number of distinct states
Y) Electrons move at a finite speed less than the speed of light
Z) Electrons follow a weakly periodic potential function

ANSWER: Z) Electrons follow a weakly periodic potential function

Bonus

6) *Physics – Short Answer:* A train of proper length L is traveling at a speed of ⅔c. Two clocks are placed on the train, one in the front and one in the rear. In terms of L and c, what is the difference in times shown on the two clocks as measured by an external observer?

ANSWER: $2L / 3c^2$

Tossup

7) *Math – Short Answer:* What are the solutions to the characteristic polynomial for the differential equation x''' - 5x'' + 6x' = 0 **[READ: x triple prime minus 5 times x double prime plus 6 times x prime equals 0]**.

ANSWER: 0, 2, 3

Bonus

7) *Math – Short Answer:* What is the smallest possible degree of the polynomial with rational coefficients that has $\sqrt{2} + \sqrt{3}$ as a root?

ANSWER: 4

Tossup

8) *Energy – Multiple Choice:* Researchers at Lawrence Berkeley National Laboratory are studying the effects of insulin on glucose transportation. Which of the following glucose transporters is glucose dependent?

W) GLUT 1
X) GLUT 2
Y) GLUT 3
Z) GLUT 4

ANSWER: Z) GLUT 4

Bonus

8) *Energy – Multiple Choice:* Scientists at Oak Ridge National Lab are studying the methods of apoptosis across many organisms. What protein in C. Elegans acts as a negative regulator of apoptosis, inhibiting cell death?

ANSWER: Ced9

Tossup

9) *Biology – Multiple Choice:* Select all of the following organelles that are considered to be reduced forms of mitochondria?

1) Kinetoplasts
2) Mitosomes
3) Hydrogenosomes

Answer: 2 and 3

Bonus

9) *Biology – Short Answer:* Which of the following 4 enzymes is incorrectly paired to its role in eukaryotic DNA replication?

I) DNA polymerase delta: synthesis of the leading strand
II) DNA polymerase gamma: synthesis of the lagging strand
III) DNA polymerase alpha: initiation of replication
IV) DNA polymerase epsilon: replication of mitochondrial DNA

ANSWER: I, II, IV

Tossup

10) *Math – Short Answer:* What is the remainder when 11^{482} is divided by 32?

ANSWER: 25

Bonus

10) *Math – Short Answer:* What type of integration, commonly used in measure theory, splits the range of a function into separate components to sum over based on the value of a defining measure for that function?

ANSWER: Lebesgue integration (Accept le-bes-gue or le-bay-ge pronunciation)

Tossup

11) *Earth and Space – Multiple Choice:* Which of the following statements about global temperatures through geologic time is true?

W) There was a gradual increase in temperature throughout the Eocene epoch.

X) The boundary between the Paleocene and Eocene was marked by a sharp increase in global temperatures.

Y) The younger dryas was marked by a sharp drop in global temperatures.

Z) There was a gradual decrease in temperatures throughout the holocene epoch

ANSWER: X) The boundary between the Paleocene and Eocene was marked by a sharp increase in global temperatures.

Tossup

11) *Earth and Space – Multiple Choice:* Identify all of the following 3 statements that are true of solar insolation on earth:

I) On average, insolation at the top of the atmosphere is higher than at the surface

II) On average, insolation received at the ocean surface is lower than insolation received on land.

III) For a given region at a given time of year, insolation received on days of colder weather should be lower than insolation received on days of warmer weather.

ANSWER: I, II

Tossup

12) *Physics – Short Answer:* Consider an infinite square potential well with a zero point energy of 15 electron Volts. How many total energy levels are there with an energy below 750 electron Volts?

ANSWER: 7

Bonus

12) *Physics – Multiple Choice:* Rohit and Matthew are making a tower out of their 10 inch tall rolled up Ocean Science Bowl posters. They put one poster inside another and put their trophy on top to see how far one poster slides into the other. The posters are rolled to a 2 inch diameter and constrained so their diameter does not change, causing the inner poster to put a pressure of 2 PSI outwards onto the outer poster. If the coefficient of friction for the posters is .5, to the nearest tenth of an inch, how far does one poster slide into the other once a 3.14 lb trophy is placed on the tower?

ANSWER: 19.5 in

Tossup

13) *Chemistry – Short Answer:* Order the following conformations of cyclohexane from highest to lowest energy; 1) Half Chair; 2) Chair; 3) Boat; 4) Twist Boat.

ANSWER: 1, 3, 4, 2

Bonus

13) *Chemistry – Multiple Choice:* Which of the following is antiaromatic, but not nonaromatic?

W) Cyclohexane
X) Pyrimidine
Y) Cyclopentadiene
Z) Cyclobutadiene

ANSWER: Z) Cyclobutadiene

Tossup

14) *Earth and Space – Multiple Choice:* According to Andersonian fault theory, which of the following is true of Normal Faults?

W) The largest stress is oriented parallel to the direction of strike
X) The largest stress is oriented parallel to the direction of dip
Y) The largest stress is oriented parallel to the cross product of strike and dip
Z) The largest stress is oriented vertically

ANSWER: Z) The largest stress is oriented vertically

Tossup

14) *Earth and Space – Short Answer:* Enriched Mid Ocean Ridge Basalts are a family of basalts enriched in incompatible rare earth metals. Iceland shows a range of Enriched Mid Ocean Ridge Basalts as well as intermediate mineral assemblages that had previously undergone fractionation crystallization called Icelandites. Identify all of the following 4 species which would occur in higher concentrations in Icelandites than the Enriched Mid Ocean Ridge Basalts:

I) Iron Oxide
II) Magnesium Oxide
III) Silica
IV) Alkalines

ANSWER: I, III, IV

Tossup

15) *Biology – Short Answer:* What paradox regarding protein folding states that there are too many possible states for a protein that exist for it to ever reach its native conformation in a reasonable amount of time

ANSWER: Levinthal's paradox

Bonus

15) *Biology – Short Answer:* Identify all of the following 4 phyla of fungi that lack flagella:

I) Ascomycetes
II) Chytrids
III) Cryptomycetes
IV) Mucoromycetes

ANSWER: I, IV

Tossup

16) *Physics – Multiple Choice:* Which of the following thermodynamic potentials is correctly matched with its natural variables?

W) Helmholtz free energy: pressure and volume
X) Internal energy: temperature and pressure
Y) Gibbs free energy: volume and temperature
Z) Enthalpy: pressure and entropy

ANSWER: Z) Enthalpy: pressure and entropy

Bonus

16) *Physics – Multiple Choice:* Two flashes of light occur at two points in spacetime. Four different observers report the distances and times between the two flashes that they observed, but one of them is lying and has reported fabricated numbers. Which of the following observations is fabricated?

W) $\Delta x = 2\sqrt{10}$, $c\Delta t = 10$
X) $\Delta x = \sqrt{10}$, $c\Delta t = 2\sqrt{15}$
Y) $\Delta x = \sqrt{15}$, $c\Delta t = 5\sqrt{3}$
Z) $\Delta x = 0$, $c\Delta t = 2\sqrt{15}$

ANSWER: X) $\Delta x = \sqrt{10}$, $c\Delta t = 2\sqrt{15}$

Tossup

17) *Earth and Space – Short Answer:* Order the following variable stars in order of least to greatest Luminosity to Mass Ratio at its average luminosity.

1) Omicron Ceti
2) RR Lyrae
3) Delta Cephei

ANSWER: 2, 3, 1

Bonus

17) *Earth and Space – Short Answer:* Identify all of the following three processes that are primary drivers of Jupiter's belt and zone circulation:

I) Differing Albedos between zones and belts
II) Varying solar insolation across latitudes
III) Jupiter's rotation

ANSWER: II and III

Tossup

18) *Biology – Short Answer:* What is the name for the protective layer of tissue surrounding embryonic roots in monocots?

ANSWER: Coleorhiza

Bonus

18) *Biology – Short Answer:* Identify all of the following 3 statements which distinguish type 3 CRISPR systems from others

I) Type III systems can target both foreign DNA and RNA
II) Type III systems do not need a PAM sequence for interference
III) Type III systems only use one enzyme to carry out interference

ANSWER: I, II

Tossup

19) *Math – Short Answer:* Sukrith writes the numbers from 1 to 5 on a whiteboard. Every minute, he chooses two numbers a and b, erases them, and writes the square root of $a^2 + b^2$ in their place. He continues doing this until there is only 1 number left on the board. What is the maximum possible value of this number?

ANSWER: sqrt(55)

Bonus

19) *Math – Short Answer:* What is the second order MacLaurin approximation of ln(1 + x) **[READ: natural log of the quantity 1 plus x]** at x = 3?

ANSWER: -3/2

Tossup

20) *Chemistry – Multiple Choice:* Which of the following polyprotic acids forms an intramolecular hydrogen bond on its first dissociation step?

W) Ascorbic Acid
X) Fumaric Acid
Y) Maleic Acid
Z) Succinic Acid

ANSWER: Y) Maleic Acid

Bonus

20) *Chemistry – Multiple Choice:* Order the following 4 solvents in order of increasing acidity of HNO_2 in them:

1) Water
2) HCl
3) Benzene
4) NaOH

ANSWER: 2, 3, 1, 4

Tossup

21) *Earth and Space – Short Answer:* Identify all of the following three statements that are true of white dwarfs:

I) As their mass increases their radius decreases
II) The limit on the size of a white dwarf is exactly half of the limit on the size of a neutron star
III) White dwarfs cannot be formed from main sequence stars of mass under 2 solar masses

ANSWER: I only

Bonus

21) *Earth and Space – Multiple Choice:* Which of the following describes the relationship between luminosity and the stellar velocity dispersion of elliptical galaxies?

W) Faber-Jackson Relation
X) Tully-Fisher Relation
Y) Sigma-D Relation
Z) M-Sigma Relation

ANSWER: W) Faber-Jackson Relation

Tossup

22) *Energy – Short Answer:* Scientists at Fermilab are studying the simulation of quantum field theories using quantum computing. What formulation of quantum field theories involves summing over the many paths a quantum particle could take to compute a probability amplitude?

ANSWER: Path integral formulation

Bonus

22) *Energy – Short Answer:* Scientists at Fermilab are studying extensions of quantum chromodynamics that involve finite dimensional path integrals, unlike traditional quantum field theories. Renormalization effectively deals with infinities arising from what analytical method used to solve for interactions in quantum field theory?

ANSWER: Perturbative expansion (ACCEPT: perturbation theory)

Tossup

23) *Chemistry – Multiple Choice:* Which of the following ligands cannot participate in pi backbonding?

W) Tetrafluoroethylene
X) Hexafluoro-2-butyne
Y) Phosphine
Z) Oxalate

ANSWER: Z) Oxalate

Bonus

23) *Chemistry – Short Answer:* Identify all of the following three directing groups that are both activating and meta-directors.

I) Akonyl
II) Chloro
III) Sulfonyl

ANSWER: None