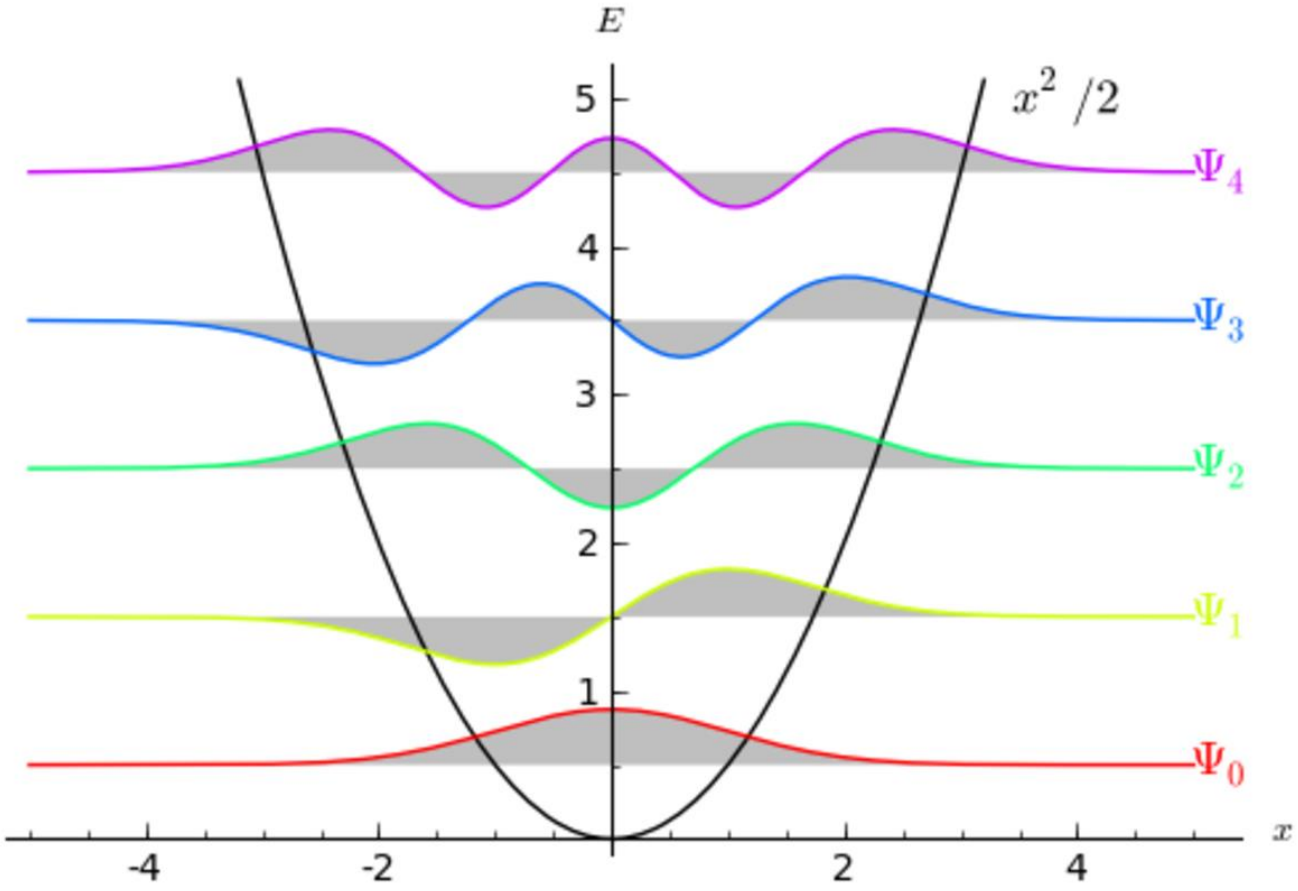
TOSS-UP

1) Physics – *Short Answer* If a parallel plate capacitor has its plate separation doubled, and the frequency of the AC current through the capacitor is tripled, then by what factor is the capacitive reactance of the capacitor multiplied?

ANSWER: 1/6 (NOTE: $1/2\pi fC$) [GW, Circuits]

VISHWAL BONUS



1) Physics – *Short Answer* Shown in the image are the energy levels of a quantum system. Answer the following three questions:

I) What is the name of this system?
II) What operator is used to get the energy eigenvalue for psi-sub-1 given the energy eigenvalue for psi-sub-0?
III) What polynomials appear in the solutions to the Schrodinger equation for this system?

ANSWER: I) QUANTUM HARMONIC OSCILLATOR (ACCEPT: QHO); II) RAISING OPERATOR (ACCEPT: CREATION OPERATOR) III) HERMITE POLYNOMIALS [GW, Quantum]

TOSS-UP

2) Biology – *Multiple Choice* Release of atrial natriuretic peptide has which of the following effects on blood volume and blood pressure?

W) Lowers blood volume and lowers blood pressure
X) Lowers blood volume and increases blood pressure
Y) Increases blood volume and lowers blood pressure
Z) Increases blood volume and increases blood pressure

ANSWER: W) LOWERS BLOOD VOLUME AND LOWERS BLOOD PRESSURE [JH, HEART]

BONUS

2) Biology – *Short Answer* Identify all of the following three statements regarding hemoglobin that are true: 1) It has an increased affinity for oxygen in the R state; 2) It possesses a Hill coefficient of more than one; 3) Fetal hemoglobin has an increased affinity for 2,3 BPG when compared to adult hemoglobin.

ANSWER: ALL [SF, PROTEINS]

TOSS-UP

3) Math – *Multiple Choice* Which of the following cyclotomic polynomials has degree 8?

W) 9th cyclotomic polynomial
X) 12th cyclotomic polynomial
Y) 15th cyclotomic polynomial
Z) 18th cyclotomic polynomial

ANSWER: Y) 15TH CYCLOTOMIC POLYNOMIAL [LY, DAN AND COBY AND TIFFANY'S MATH SET]

BONUS

3) Math – *Short Answer* Jane is standing at $x = 0$ and wants to get to $x = 5$. Every second, she randomly generates an integer between 1 and 5-x inclusive, where x is her current position. Then, she moves to the right by that amount. What is the probability that she reaches $x = 5$ in exactly 2 seconds?

ANSWER: 5/12 [LY, casework]

TOSS-UP

4) Earth and Space – *Short Answer* Which plagioclase lacking rock found in fore-arcs contains high Magnesium and high Silica content, low incompatibles, and is considered primitive to Andesite, Dacite and Rhyolite?

ANSWER: BONINITE [JY, hard as rocks]

BONUS

4) Earth and Space – *Short Answer* Irradiation from UV or cosmic rays can form many organic compounds from bases of carbon dioxide or methane. What is the general term for these irradiated compounds, which are commonly found as a reddish hue on bodies like Charon and Titan?

ANSWER: THOLINS [LY, SBL ADJACENT NGL]

TOSS-UP

5) Chemistry – *Short Answer* EPR spectroscopy distinguishes chemical environments of unpaired electrons by measuring the value of what quantity which relates the angular momentum of an electron to its magnetic moment?

ANSWER: G-FACTOR (ACCEPT: G-VALUE) [BZ, spec]

BONUS

5) Chemistry – *Short Answer* Given that aspartic acid has pKa values of 1.9 and 3.5 on its carboxyl groups, and a pKb value of 4.4 on its amino group, what is the value of the isoelectronic point?

ANSWER: 2.7 [BZ, biochem]

TOSS-UP

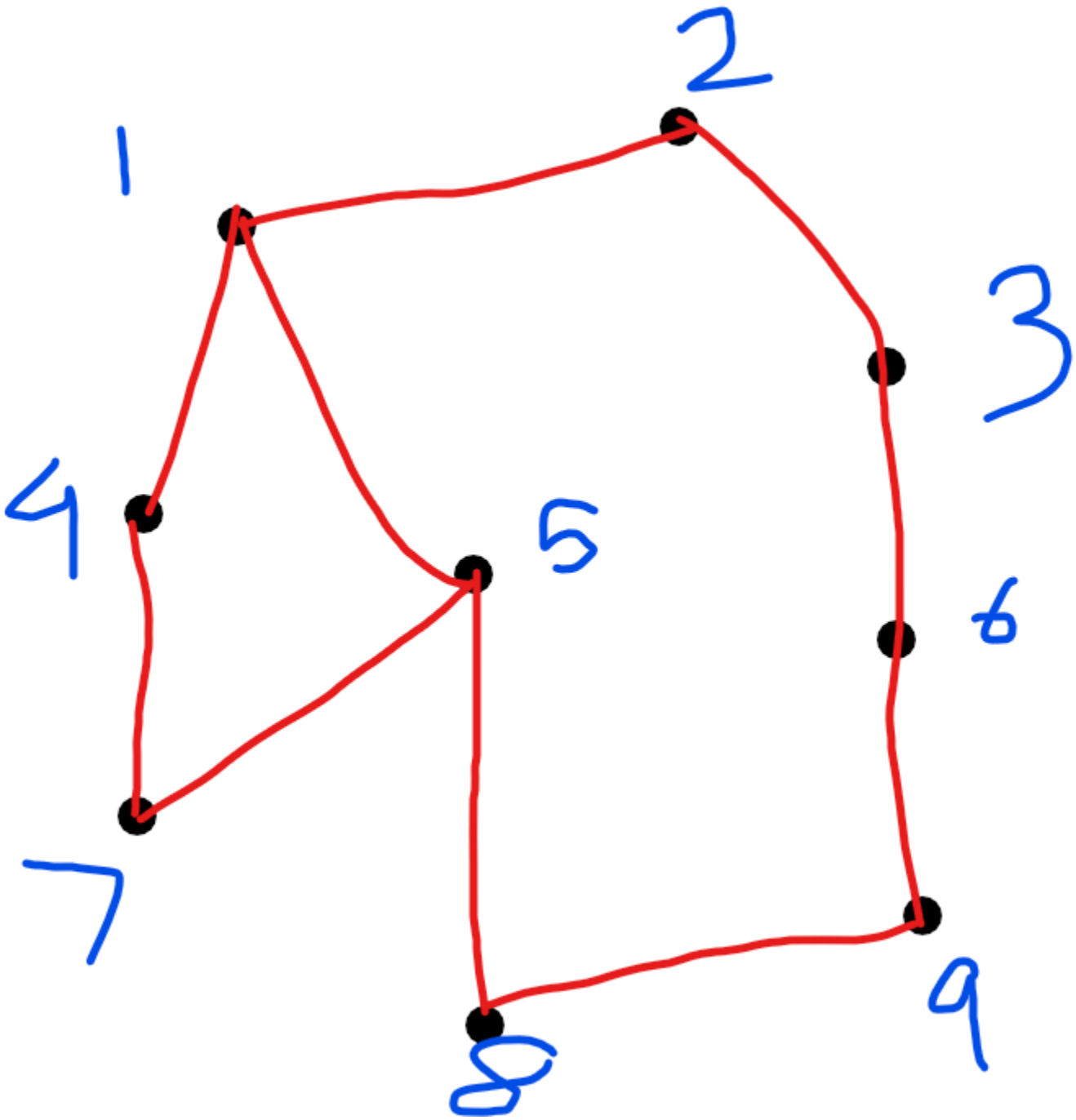
6) Energy – *Multiple Choice* Researchers got a 75% in machine programming, and therefore got a C. In C, which of the following would most likely occur when trying to access the value of an int array exactly 1 index after its end?

W) Returns a value of zero
X) Random garbage
Y) Segmentation fault

Z) Out-of-bounds error

ANSWER: X) RANDOM GARBAGE [GW, C CS]

VISHWAL BONUS



6) Energy – *Short Answer* Scientists at Sandia National Lab are investigating efficient solutions to the traveling salesman problem. One type of path they are looking at is a path that

traverses every edge in the graph exactly once. Answer the following two questions about the graph shown in the image:

I) What is the name for this kind of path?
II) Assuming that such a path exists for this graph, what two vertices must be the start and end points?

ANSWER: I) EULERIAN PATH; II) 1 AND 5 [LY, david]

TOSS-UP

7) Physics – *Short Answer* Paul Dirac showed that the existence of magnetic monopoles would imply the quantization of what quantity?

ANSWER: CHARGE (ACCEPT: ELECTRIC CHARGE) [GW, Stock]

BONUS

7) Physics – *Short Answer* A circular rope with a radius of 1 meter is spinning in the absence of external forces at an angular speed of 10 radians/second. If the mass of the rope is 0.3 kilograms, then in terms of π, what is the tension in the rope?

ANSWER: 15/π NEWTONS [GW, Circles]

TOSS-UP

8) Biology – *Multiple Choice* Which of the following is NOT true about genetic hitchhiking?

W) Genetic hitchhiking is caused by stochastic forces.
X) The hitchhiking gene is likely not undergoing a selective sweep.
Y) The occurrence of genetic hitchhiking supports the neutral theory of evolution.
Z) Genetic hitchhiking causes linkage disequilibrium.

ANSWER: Y) THE OCCURRENCE OF GENETIC HITCHHIKING SUPPORTS THE NEUTRAL THEORY OF EVOLUTION [JH, POP GEN]

BONUS

8) Biology – *Short Answer*. Identify all of the following four structures that can be found in an organism given that its coelom formed from folds in the archenteron: 1) Cecum; 2) Mantle; 3) Scolex; 4) Tube feet

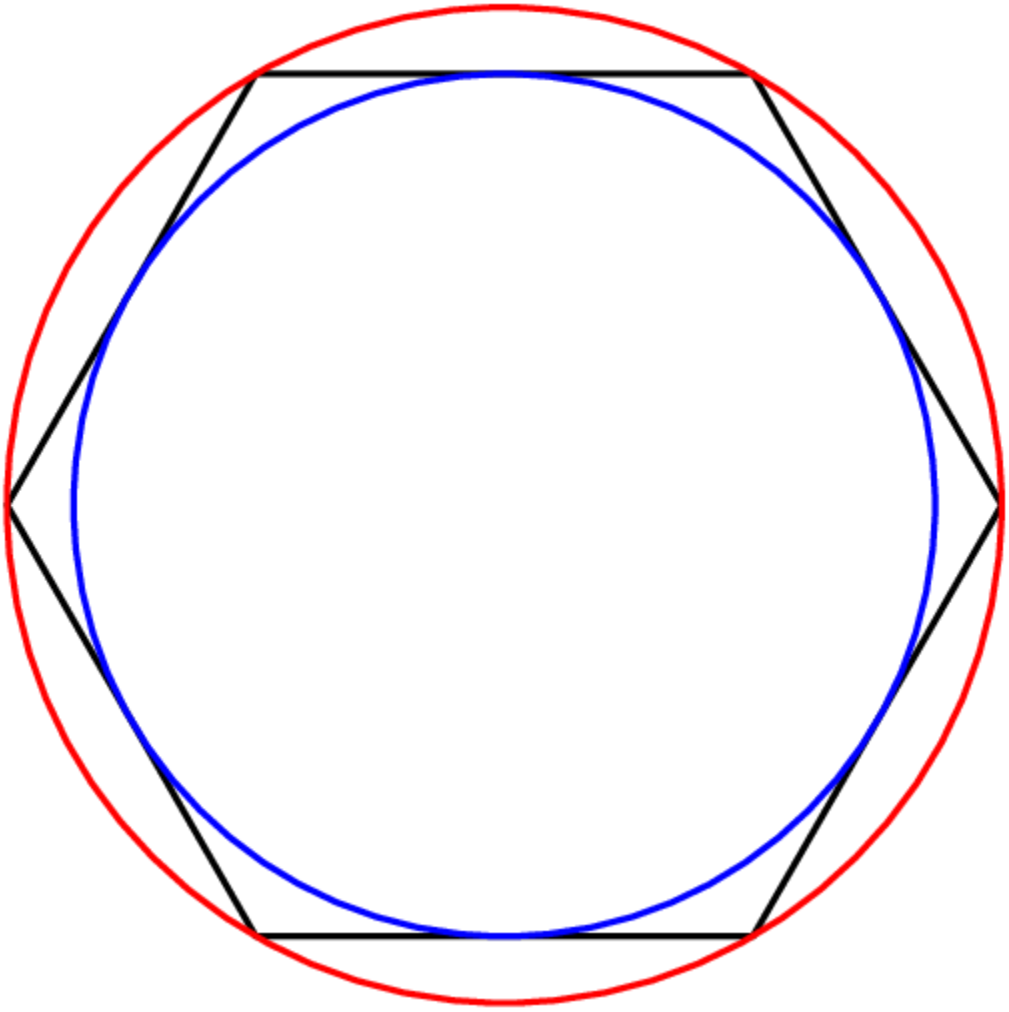
ANSWER: 1 AND 4 [JH, DEUTEROSTOME]

TOSS-UP

9) Math – *Short Answer* Identify all of the following 3 statements about the Fibonacci numbers that are TRUE: 1) For all sufficiently large integers, there exists exactly one way to express them as a sum of distinct Fibonacci terms; 2) The closed form formula of the Fibonacci numbers has dominant term equal to the golden ratio; 3) The sum of so-called “shallow” diagonals in Pascal's triangle yield Fibonacci numbers.

ANSWER: 2 AND 3 [LY, bait]

VISUAL BONUS



9) Math – *Short Answer* For integers n above 2, let $f(n)$ be the ratio of the areas of the inscribed and circumscribed circles of a regular n-gon. For example, the image shows $f(6)$ as the ratio of the area of the blue circle to that of the red circle. Compute the limit as n goes to infinity of n squared times quantity 1 minus $f(n)$.

ANSWER: PI SQUARED [LY, GEOMETRIC LIMITATIONS]

TOSS-UP

10) Earth and Space – *Short Answer* Stars in the arms of spiral galaxies are stabilized as long as their rotation speed is within kappa over m of the global pattern speed, where kappa is the epicyclic frequency and m is the number of arms in the galaxy. What specific form of resonance with "inner" and "outer" forms is responsible for this phenomenon?

ANSWER: LINDBLAD RESONANCE (ACCEPT: ILR; ACCEPT: OLR) [LY, IF YOU HAVE A SHIT BONUS PUT IT AFTER THIS ONE]

BONUS

10) Earth and Space – *Short Answer* You are walking from west to east across a fault, and notice that the surface rock on the east side is from the Triassic and the rock on the west side is from the Pennsylvanian. Somebody tells you that the fault dips toward the west at 50 degrees. Answer the following 2 questions:

I) What type of fault would this be?

II) Using Anderson's theory of faults, rank the following 3 directions of stress from highest to lowest, assuming that the area has remained stationary since fault formation: 1) east-west; 2) north-south; 3) up-down.

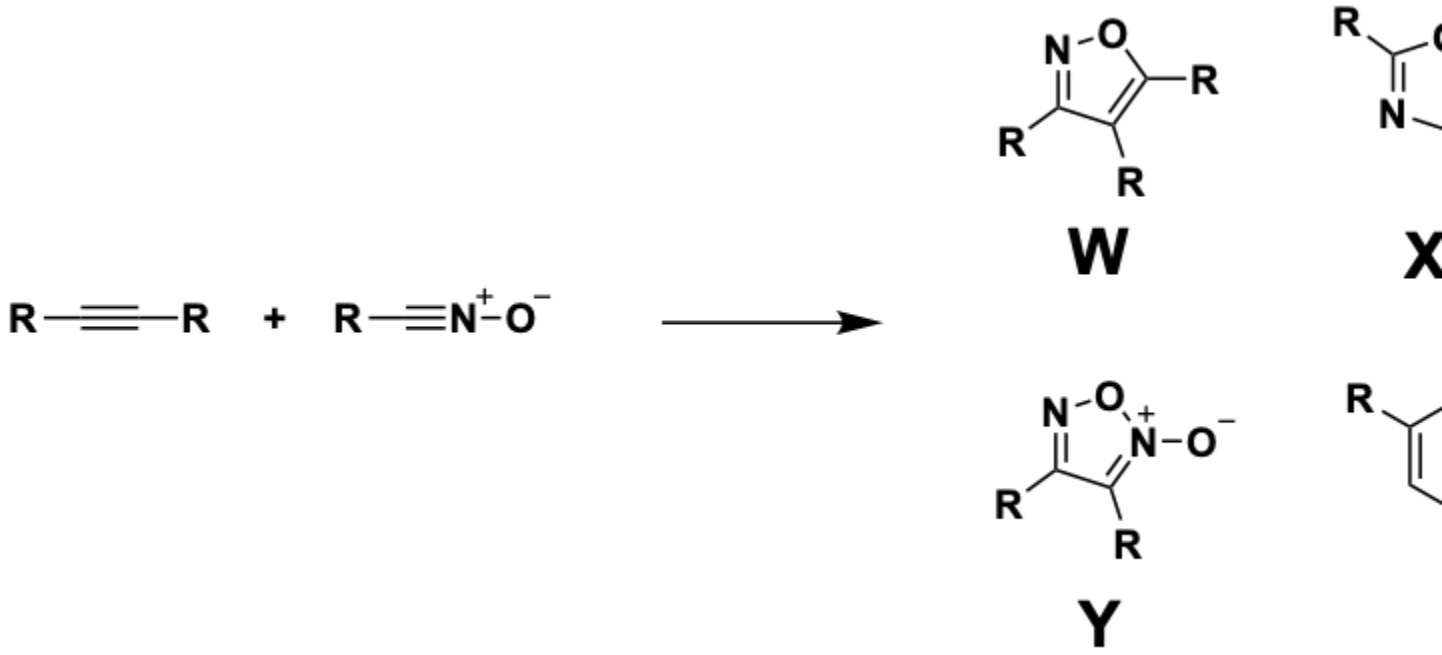
ANSWER: I) REVERSE; 2) 1, 2, 3 [JY, hard as rocks]

TOSS-UP

11) Chemistry – *Short Answer* Rank the following 3 d electron configurations in order of increasing Jahn-Teller stabilization in an octahedral crystal field: 1) d2; 2) d3, 3) d9.

ANSWER: 2, 1, 3 [BZ, inorgo]

VISHWAL BONUS



11) Chemistry – *Short Answer* Shown in the image is a dipolar cycloaddition reaction. Answer the following three questions regarding the image: 1) What is the name of the dipole that reacts? 2) What product is formed in the dipolar cycloaddition? 3) What product is formed as an unwanted side product?

ANSWER: 1) NITRILE OXIDE; 2) W; 3) Y [NE, NEdumbassery]