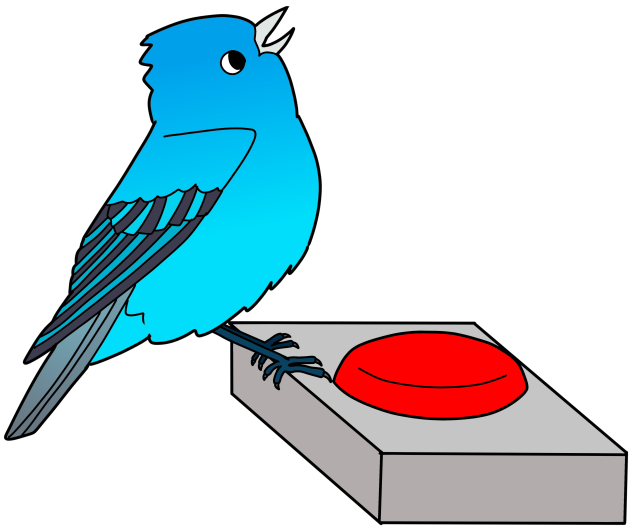
Science Quiz Bowl C

BirdSO Mini 2021-22

11-18 December 2021



- You will have 50 minutes.
- This test will have 5 sections: Biology, Chemistry, Physics, Earth/Space Science, and Miscellaneous. Each section will have **30 questions**, each worth 1 point.
- Choose the ONE best answer for each question unless otherwise noted.
- A non-programmable, non-graphing calculator, writing utensils, and your brain are permitted.
- Special thank you to all the BirdSO Event Supervisors who contributed questions to Science Quiz Bowl! This exam was crowdsourced, and it would not have been possible without all of them.

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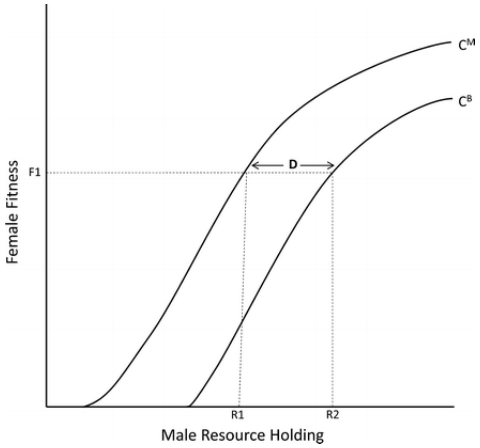
1 Biology

Choose the ONE best answer for each question unless otherwise noted.

1. Which of the following polypeptides is likely least soluble in water?
    A. Trp - His - Ser - Val
    B. His - Leu - Asn - Thr
    C. Ile - Met - Ala - Val
    D. Arg - Asp - Gly - Asn
2. Disulfide bonds will form between two residues of which amino acid?
    A. Methionine
    B. Threonine
    C. Serine
    D. Cysteine
3. Which amino acid is least likely to be found in the middle of alpha helices?
    A. Proline
    B. Methionine
    C. Aspartic Acid
    D. Valine
4. If a diploid human cell in G0 or G1 has 46 uncondensed chromosomes, how many chromatids will the cell have when it goes through S and G2 and enters prophase?
    A. 23
    B. 46
    C. 92
    D. 184
5. What is the F2 phenotypic ratio in a monohybrid cross with a single gene with a dominant and recessive allele (heterozygous)?
    A. 1:2:1
    B. 1:1
    C. 9:3:3:1
    D. 3:1
6. Which portion of the eye is responsible for detecting light?
    A. Iris
    B. Retina
    C. Cornea
    D. Vitreous humor
7. Which of the following is not a function of the tumor suppressor p53?
    A. Activating DNA repair enzymes
    B. Triggering production of cyclin-dependent kinase (Cdk) inhibitors
    C. Triggering programmed cell death
    D. All of the above are functions of p53
8. What is not one immediate development experienced by aquatic tetrapods in their transition to land?
    A. Appearance of a middle ear structure
    B. An independent pectoral girdle
    C. The beginnings of inertial feeding
    D. The use of external fertilization
9. Let the diameter of a double-stranded DNA molecule be about 20 angstroms. Each helix will rise 34 angstroms in one complete turn. Given that there are 3.5×10^9 complete turns, estimate the length of the strand.
    A. 2.50×10^{11} angstroms
    B. $3.74 * 10^{12}$ angstroms
    C. $7.48 * 10^{12}$ angstroms
    D. $3.95 * 10^{13}$ angstroms
10. What is the heterochronic process that is partially defined by the earlier than usual onset of ontogenetic processes?
    A. Paedomorphosis
    B. Peramorphosis
    C. Isomorphosis
    D. Neoteny
11. Which of the following diseases are not caused by prions?
    A. Chronic Wasting Disease
    B. Gerstmann–Sträussler–Scheinker syndrome
    C. Alpers-Huttenlocher Syndrome
    D. Laughing Sickness
12. Which of the following types of organisms is not an acoelomate?
    A. Flatworms
    B. Roundworms
    C. Cnidarians
    D. Poriferans
13. What type of detention is found in bony fish?
    A. Acrodont
    B. Pleurodont
    C. Thecodont
    D. Heterodont
14. Which adrenergic agent can stimulate an animal's heart to beat?
    A. Phenylpropanolamine
    B. Epinephrine
    C. Albuterol
    D. Dopamine

15. What type of antibody is produced during a secondary immune response?
    A. IgA
    B. IgG
    C. IgD
    D. IgE
16. What is the term for variations in erythrocyte size in a blood sample?
    A. Anisocytosis
    B. Poikilocytosis
    C. Microcytosis
    D. Macrocytosis
17. What type of injections are used when administering a tuberculin test?
    A. Subcutaneous
    B. Intramuscular
    C. Intradermal
    D. Intraosseous
18. The CLAW hypothesis states that
    A. Dimethyl sulfide exponentially increases the phytoplankton's response to climate variation, logarithmically increasing the earth's temperature.
    B. Dimethyl sulfide producing phytoplankton decline as a response to climate variations, leading to a warming of global temperatures
    C. Dimethyl sulfide is a strong greenhouse gas that traps infrared radiation, leading to warming of global temperatures
    D. Dimethyl sulfide producing phytoplankton are responsive to variations in climate changes, and those changes help stabilize the earth's atmospheric temperature
19. Suppose you have immature cells arrested during the G2 phase of the cell cycle, but you want them to continue into mitosis. What is one component that would need to be added to ensure the continuation of the cell cycle for these cells?
    A. Cyclin E and Cyclin D
    B. Cyclin C and Cyclin B
    C. Cyclin B and Cyclin A
    D. Cyclin C and Cyclin A
20. Which biological experiment proved the semi-conservative theory of DNA replication?
    A. Thomas Hunt Morgan's experiment
    B. Griffith's experiment
    C. Hershey–Chase experiment
    D. Meselson–Stahl experiment
21. In angiogenesis, which step occurs directly before the pruning of vessels?
    A. Endothelial cell proliferation
    B. Tubulogenesis
    C. Vessel fusion
    D. Pericyte stabilization
22. What type of dimorphism do the leaves on certain species of ferns exhibit?
    A. Frond dimorphism
    B. Sexual dimorphism
    C. Nuclear dimorphism
    D. Root dimorphism
23. The glycoalkaloid solanine is prevalent in the following plants except
    A. Nightshade
    B. Potatoes
    C. Tobacco
    D. Onions
24. Which of the following terms describes the mating of two organisms that are phenotypically similar?
    A. Inbreeding
    B. Backcrossing
    C. Random assortment
    D. Assortative mating
25. What is an example of a proximate question?
    A. Does increased parental attention and care increase survival?
    B. Is a moth's wing color genetically determined?
    C. Why do babies cry?
    D. Do flocking behaviors make foraging safer?
26. What does an indirect Coombs titer of 32 indicate?
    A. It takes more than 31 parts diluent to abolish a positive indirect Coombs test.
    B. It takes more than 31 parts diluent to abolish a negative indirect Coombs test.
    C. It takes exactly 32 parts diluent to abolish a positive indirect Coombs test.
    D. It takes exactly 33 parts diluent to abolish a negative indirect Coombs test.
27. Examples of porphyrins include all of the following except:
    A. Bilirubin
    B. Turacoverdin
    C. Psittacofulvins
    D. Porphin

28. What is the first intermediate host of the chinese liver fluke?
    A. Freshwater fish
    B. Freshwater snail
    C. Humans
    D. Cattle
29. The diagram illustrates which of the following?



    A. Good genes hypothesis
    B. Thrifty gene hypothesis
    C. Dual mating hypothesis
    D. Polygyny threshold hypothesis
30. What factor may have caused the genetic disorder hemochromatosis to be selected for and become relatively common among Northern European ancestry?
    A. Hemochromatosis causes cells to absorb and build up iron away from the bacteria, and gives those with hemochromatosis a better chance of surviving the bubonic plague.
    B. The excess iron buildup from hemochromatosis causes the body to be able to better withstand colder temperatures, increasing the survival rates of humans present in the Younger Dryas, or the last ice age.
    C. The build up of iron in cells causes anemia, which destroys red blood cells. This offers protection from Malaria, which ravaged human populations.
    D. The increased iron concentration in the skin cells allows for better absorption of sunlight. This helped with vitamin D deficiencies common among Northern European populations.

2 Chemistry

1. Which would you expect to react with bromocyclohexane via a SN_2 mechanism?
   A. C_2H_5OH
   B. KCN
   C. $(CH_3)_2NH$
   D. KC_2H_5O
2. Which reagent can convert a primary alcohol into an aldehyde?
   A. PCC
   B. DMSO
   C. $LiAlH_4$
   D. NBS
3. Which of the following specific heat capacity values would cause the substance to exhibit the lowest temperature change?
   A. c = 0.87 kJ/kg K
   B. c = 0.24 kJ/kg K
   C. c = 0.76 kJ/kg K
   D. c = 1.03 kJ/kg K
4. Which of the following combinations must produce a negative change in internal energy?
   A. Work is done on the system. The system absorbs heat from the surroundings.
   B. A gas expands in volume. Heat is evolved to the surroundings.
   C. A gas compresses in volume. Heat is evolved to the surroundings.
   D. An isolated system is present.
5. Which of the following cannot be a Bronsted-Lowry base?
   A. H_2O
   B. NH_4^+
   C. H_2S
   D. OH^-
6. Which of the following compounds would have the highest boiling point?
   A. SiC
   B. $NaCl$
   C. Na
   D. SiH_2
7. Consider an electron in a system that can be described by the particle in a box model. The electron absorbs 560 nm of light to transition from the $n = 1$ to the $n = 2$ state in a box of a certain length. What is this length, in Angstroms?
   A. 5.10 A
   B. 7.14 A
   C. 8.91 A
   D. 5.83 A
8. Which class of organic compounds below does NOT contain oxygen?
   A. Alcohol
   B. Amine
   C. Amide
   D. Ketone
9. Which of the following contains exactly one triple bond?
   A. C_5H_{10}
   B. C_5H_{12}
   C. C_6H_{10}
   D. C_6H_{12}
10. Which base is most suited for preparing a buffer solution with a pH= 11.0?
    A. Aniline ($K_b = 4.0 \times 10^{-10}$)
    B. Pyridine ($K_b = 1.7 \times 10^{-9}$)
    C. Ammonia ($K_b = 1.8 \times 10^{-5}$)
    D. Methylamine ($K_b = 4.4 \times 10^{-5}$)
11. The element chromium can take a variety of oxidation states and a variety of ligands, depending on the compound in which it is found. The colors of these compounds vary, but include all four of the colors in the Google Chrome logo. Which of the following chromium compounds is yellow?

    A. $CrCl_2$ (aq)
    B. $CrCl_3$ (aq)
    C. CrO_3 (s)
    D. Na_2CrO_4 (aq)

12. In some scientific applications where things need to be cooled to extremely low temperatures, the "reaction" of mixing liquid Helium-3 and Helium-4 is used. Which of the following is true of this reaction?
    A. It has positive enthalpy and negative entropy.
    B. It has positive enthalpy and positive entropy.
    C. It has negative enthalpy and negative entropy.
    D. It has negative enthalpy and positive entropy.
13. Which of the statements is true of the following unbalanced reaction:
    $\mathrm{Na_2CO_3 + CO2 + H_2O \rightarrow NaOH + H_2CO_3}$
    A. There are no positive integer values for coefficients that balance the reaction.
    B. The reaction can be balanced, but only in a way or ways that imply the reaction to have involved oxidation and reduction.
    C. The reaction can be balanced in exactly one way with positive integer coefficients that have no common factor, and that way does not imply oxidation and reduction to have occurred.
    D. The reaction can be balanced in multiple ways with positive integer coefficients that have no common factor, and at least one of those ways does not imply oxidation or reduction.
14. Which of the following ions has the largest ionic radius?
    A. $\mathrm{Cl^-}$
    B. $\mathrm{Sr_2^+}$
    C. $\mathrm{Li^+}$
    D. $\mathrm{S_2^-}$
15. Which of the following cannot increase the rate of a reaction?
    A. Shining a bright light in the ultraviolet spectrum onto the reactants
    B. Decreasing the volume of the reaction chamber to increase the pressure
    C. Increasing the concentration of the products of the reaction by dissolving more product in the solution
    D. Adding an inert gas to the reaction chamber to increase the pressure
16. What is the point group symmetry of the molecule trans-$\mathrm{[Os(CO)_4Cl_2]}$?
    A. D_{4h}
    B. O_h
    C. D_{2h}
    D. T_d
17. Which orbital is represented by the polar equation: $\sin\theta^2 \cdot \cos\theta \cdot \cos 2\phi$?
    A. f_{xyz}
    B. $f_{(x^2-y^2)z}$
    C. d_{xy}
    D. $d_{x^2-y^2}$
18. What is the oxidation state of the transition metal present in mer-$\mathrm{K[W(CO)_3(CN)_3]}$?
    A. +2
    B. +3
    C. +5
    D. +6
19. Under the VSEPR model what is the molecular shape of $\mathrm{XeSCl_4}$?
    A. Trigonal bipyramidal
    B. Octahedral
    C. Square pyramidal
    D. See-saw
20. What is the name of the compound $\mathrm{Na_3[Fe(CN)_4F_2]}$?
    A. Sodium tetracyanodifluoroferrate(III)
    B. Sodium tetracyanidedifluoroferrate(III)
    C. Trisodium tetracyanodiflouroiron(III)
    D. Sodium tetracyanodifluoroiron(III)
21. What is the hapticity of an inorganic compound?
    A. The number of ligands formally bonded to a metal atom
    B. The total number of ligands in the inorganic compound
    C. The number of metal atoms formally bonded to a ligand
    D. The total number of metal atoms in the inorganic compound
22. Which of the following statements regarding entropy is incorrect?
    A. Entropy is a variable of state
    B. The entropy of a pure and perfectly crystalline substance at 0K is 0
    C. The entropy of the system and surroundings remains unchanged for a reversible process
    D. Entropy is an intensive property
23. The standard reduction potential for $\mathrm{Sn4^+}(aq) + 2\mathrm{e^-} \rightarrow \mathrm{Sn_2^+}(aq)$ is 0.15 Volts. The standard reduction potential for $\mathrm{Sn_2^+}(aq) + 2\mathrm{e^-} \rightarrow \mathrm{Sn}(s)$ is -0.14 Volts. What is the standard reduction potential for the reaction $\mathrm{Sn_4^+}(aq) + 4\mathrm{e^-} -> \mathrm{Sn}(s)$?
    A. 0.005 Volts
    B. 0.01 Volts
    C. 0.02 Volts
    D. 0.08 Volts

24. A gas with mass of 1.211 g and a volume of 677 mL has a pressure of 750.12 torr at 23 Celsius. Which of the following is a possible molecular formula for this gas?
    A. H2S
    B. O2
    C. CO2
    D. C2H6
25. With the reaction mechanism: $A + B \rightleftharpoons X + C$; k_1, k_{-1} as the fast step and $X + B \rightarrow D$; k_2 as the slow step, what is the overall rate law?
    A. $k_1[A][B]$
    B. $(k_1k_2/k_{-1})[A][B]^2/[C]$
    C. $k_2[X][C]$
    D. $(k_1k_2)[A][B]^2$
26. A solution of $[\mathrm{Ni(ox)_2(NH_3)_2}]$ was observed to be green. $[\mathrm{Ni(ox)_2(NH_3)_2}]$ was also found to have d^6 electrons. Which of the following statements is true?
    A. The compound is high spin and paramagnetic
    B. The compound is low spin and paramagnetic
    C. The compound is high spin and diamagnetic
    D. The compound is low spin and diamagnetic
27. How many isomers does $[\mathrm{Ni(ox)_2(NH_3)_2}]$ have?
    A. The compound does not have any isomers
    B. The compound has 2 isomers
    C. The compound has 3 isomers
    D. The compound has 5 isomers
28. What is the hybridization of $[\mathrm{Ni(CN)_4}]^{2-}$, knowing that the compound is square planar geometry?
    A. sp^3d^2
    B. sp^3
    C. dsp^2
    D. d^2sp^3
29. $K_b(\mathrm{NH_3}) = 1.76 \times 10^{-5}$. When 125 mL of 0.150 M $\mathrm{NH_3}$ is mixed with 95.0 mL of 0.050 M HCl, what is the final pH of the solution?
    A. 7.78
    B. 8.25
    C. 8.98
    D. 9.72
30. In the gaseous reaction $A(g) + B(g) \rightarrow 2C(g)$ where the initial partial pressures of reactants A and B are 5.0 atm and the initial partial pressure of product C is 0 atm, what is the final partial pressure of the product C after the reaction reaches equilibrium if the K_p of the reaction is 2.5?
    A. 3.87 atm
    B. 4.42 atm
    C. 5.67 atm
    D. 10 atm

3 Physics

1. If a 10-kilogram box slides down a 10-meter long ramp inclined at 30° above the horizontal, how much work is done by gravity on the box?
    A. 980 J
    B. 490 J
    C. -980 J
    D. -490 J
2. A rod is spinning counterclockwise in the xz-plane. Which of these is the direction of the rod's angular momentum vector?
    A. the positive z-direction
    B. the negative x-direction
    C. the positive y-direction
    D. the negative y-direction
3. What particle consists of 2 up quarks and one down quark?
    A. Proton
    B. Neutron
    C. Graviton
    D. Gluon
4. In what wavelength would the light be emitted by electron-hole recombination in Silicon crystal?
    A. 0.45 micron
    B. 1.1 micron
    C. 1.7 micron
    D. 2.7 micron
5. What is the approximate wavelength of the light emitted from a star with 6000 K surface temperature?
    A. 3800 Angstrom
    B. 4300 Angstrom
    C. 4800 Angstrom
    D. 5300 Angstrom
6. A bubble of helium (a monatomic gas) rising very fast from the bottom of the ocean expands its volume by 8 when it reaches the surface. What is the pressure at the depth where it formed?
    A. 4 atm
    B. 8 atm
    C. 16 atm
    D. 32 atm
7. What is the stored thermal energy per molecule in a crystalline solid at high temperature? (kB is Boltzmann constant, T = temperature in Kelvin)
    A. kBT
    B. kBT ln2
    C. 3kBT
    D. 10 kBT
8. What is the ultimate limit of energy required to switch a von-Neumann binary element (0 to 1)? (kB is Boltzmann constant, T = temperature in Kelvin)
    A. kBT
    B. kBT ln2
    C. 3 kBT
    D. 10 kBT
9. The phon, which measures sound loudness, is which kind of unit?
    A. Linear
    B. Logarithmic
    C. Quadratic
    D. Exponential
10. Which of the following speeds is closest to Mach 5 (in dry air at STP)?
    A. 340 m/s
    B. 1000 m/s
    C. 1700 m/s
    D. 5000 m/s
11. An approximate quadratic formula for the speed of sound in dry air with respect to temperature above 0 degrees Celsius is $331 + 0.606T - CT^2$. Which of the following is closest to C?
    A. 0.000458
    B. 0.000555
    C. 0.000742
    D. 0.001121
12. Bernoulli's equation for incompressible flows states that the sum of three of the quantities below is constant. Which of the following is not one of those quantities?
    A. Pressure
    B. Kinetic Energy
    C. Potential Energy
    D. Density
13. The speed of a traveling wave is roughly the square root of A/B. Which of the following best describe A and B?
    A. A is an elastic property, and B is an inertial property
    B. A is an inertial property, and B is an elastic property
    C. A is an elastic property, and B is a constant
    D. A is an inertial property, and B is a constant

14. A rocket is launched normal to the surface of the Earth away from the Sun. What is the minimum initial velocity required for the rocket to leave the Sun-Earth system?
    A. 20 km/s
    B. 42 km/s
    C. 60 km/s
    D. 72 km/s
15. Which of the following statements about nonconservative forces is most correct?
    A. The potential energy due to a nonconservative force at a point is proportional to the magnitude of the nonconservative force at that point.
    B. The rate at which the potential energy due to a nonconservative force changes over time at a point is proportional to the magnitude of the nonconservative force at that point.
    C. The amount which the potential energy due to a nonconservative force changes per unit distance along a line is proportional to the magnitude of the nonconservative force on that line.
    D. A nonconservative force cannot be responsible for potential energy; instead, conservative forces are responsible for potential energy.
16. A planet of negligible mass orbits around a star of 4 solar mass and a distance of 16 astronomical units. How many years will it take for the planet to make a full rotation around the central star?
    A. 2 years
    B. 4 years
    C. 16 years
    D. 32 years
17. How does the density of a black hole change as the mass of the black hole increases?
    A. The density is inversely proportional to mass
    B. The density does not depend on mass
    C. The density is directly proportional to mass
    D. The density is proportional to the square of the mass
18. The property of viscosity can best be described as which of the following?
    A. The friction between adjacent layers of fluid as they move
    B. The strength of the bonds between adjacent fluid molecules
    C. Surface tension of the fluid
    D. The amount of heat energy lost as fluid particles collide
19. Two tones of constant frequency are played from two speakers equidistant to a receiver. The speakers play at an intensity of x. If the phase difference of the speakers is 0.6 radians, what is the intensity of the sound heard by the receiver?
    A. $0.175x$
    B. $0.435x$
    C. $1.565x$
    D. $1.825x$
20. Let charge A $= 10\mu$ C and let charge B $= 20\mu$C. If charge A is initially 10m away from charge B, how much work is needed to bring charge A to a point 3m away from charge B?
    A. 0.419J
    B. 0.531J
    C. 0.819J
    D. 1.638J
21. Consider two lenses L_1 and L_2. For some positive distance d, an object is $4d$ to the left of L_1, and L_1 is $3d$ to the left of L_2. Suppose the focal lengths of L_1 and L_2 are d and $2d$, respectively. Where is the final image of the two-lens system?
    A. $4d/3$ to the right of L_2
    B. $d/2$ to the right of L_2
    C. $4d/3$ to the left of L_2
    D. $d/2$ to the left of L_2
22. Consider a uniform magnetic field with magnitude B that lies perpendicular to a circular wire loop. The magnetic field changes as t increases only inside the loop. Given that the induced EMF increases linearly with time t, then what is the magnitude of the magnetic field at time t?
    A. B
    B. t
    C. Bt
    D. t^2
23. Which of the following best describes Fermat's Principle of Ray Optics?
    A. When a ray of light changes medium, the ratio of the sines of the angles of incidence is equal to the ratio of the indices of refraction
    B. Every point on a wavefront is itself the source of infinitely many rays of light
    C. A ray of light travels between two points along the path which takes the least time
    D. A ray of light travels between three points by traveling from one point to a second point and then to the third point

24. What will the fundamental frequency be for a string of mass m, length L, and tensioned at 144 N?
    A. $12\frac{\sqrt{\frac{L}{m}}}{L}$
    B. $6\frac{\sqrt{\frac{L}{m}}}{L}$
    C. $6\frac{\sqrt{\frac{m}{L}}}{L}$
    D. $12\frac{\sqrt{\frac{m}{L}}}{L}$
25. A spring has spring constant k and is stretched by a distance d. A second spring requires twice the work to stretch by a distance of $d/2$. What is the spring constant of the second spring?
    A. $2k$
    B. $4k$
    C. $8k$
    D. $16k$
26. The Standard Model describes three of the four fundamental forces. Which force is omitted?
    A. Gravity
    B. Electromagnetism
    C. Strong Nuclear Force
    D. Weak Nuclear Force
27. A ray of light traveling through water (n=1.33) has an angle of incidence with the surface of 67.0°. The second medium is air (n = 1.00). What will be the angle of the refracted ray?
    A. 67.0°
    B. 43.8°
    C. 90.0°
    D. None of the above
28. Suppose you have a point charge of $+q$ at the corner of the cube. Which of the following is ε_0 times the flux passing through the three faces not touching the charge?
    A. 0
    B. $q/4$
    C. $q/8$
    D. $q/24$
29. Suppose there are three resistors, each with resistance R. Which of the following is the difference between the equivalent resistance of a circuit containing the three resistors in parallel and in series?
    A. $\frac{3r^2-3}{r}$
    B. $\frac{3r^2-1}{r}$
    C. $\frac{r^2-1}{6}$
    D. $\frac{r^2+1}{3}$
30. Suppose an electron moves right into a magnetic field going into a page. Which way would a force act upon the electron?
    A. Up
    B. Down
    C. Out of the page
    D. Right

4 Earth/Space Science

1. Which of the following are not a glacial landform?
   A. Roches moutonnée
   B. Pingos
   C. Erratics
   D. Eskers
2. Which type of precipitation is formed when snow falls into a shallow warm layer then a deep freezing layer?
   A. Hail
   B. Graupel
   C. Sleet
   D. Freezing rain
3. Which of these minerals would be the first to crystallize from a cooling magma?
   A. Pyroxene
   B. Biotite
   C. Muscovite
   D. Olivine
4. At which of the following latitudes do the Ferrel and Hadley cells meet?
   A. 0°
   B. 30°N and 30°S
   C. 60°N and 60°S
   D. 90°N and 90°S
5. Which of these is the main constituent of Mars' atmosphere?
   A. Nitrogen
   B. Carbon dioxide
   C. Hydrogen
   D. Carbon monoxide
6. If the hanging wall moves down relative to the footwall, and the fault is angled at 5 degrees below the horizontal axis, what type of fault is this?
   A. Strike-slip fault
   B. Thrust fault
   C. Reverse fault
   D. Normal fault
7. In the Northern Hemisphere, if a low pressure system were located to your north and a high pressure system were located to your south, what is the most likely wind direction at your location?
   A. Northwest
   B. Northeast
   C. Southeast
   D. Southwest
8. What astronomical object has gravity so powerful that not even light can escape its surface?
   A. Black hole
   B. Neutron star
   C. White dwarf
   D. Brown dwarf
9. What moon of Jupiter is known for its volcanic activity?
   A. Ganymede
   B. Europa
   C. Io
   D. Callisto
10. What process governs the creation of helium in the cores of low-mass main sequence stars?
    A. CNO cycle
    B. Proton-proton chain
    C. Triple-alpha process
    D. R-process nucleosynthesis
11. What object doesn't have enough mass to be able to fuse hydrogen into helium in its core?
    A. Brown dwarf
    B. Galaxy
    C. White dwarf
    D. Neutron star
12. What type of galaxy usually forms from the collision of 2 spiral galaxies?
    A. Irregular
    B. Spiral
    C. Elliptical
    D. Barred spiral
13. The thermosphere (80 km to 690 km) can have gas reaching as high as what temperature?
    A. -15 °C
    B. 17 °C
    C. -120 °C
    D. 2000 °C
14. Neptune and Uranus are much smaller than Jupiter and Saturn because of which of the following?
    A. Jupiter's gravitational effects
    B. Solar wind pushing more materials to Jupiter/Saturn
    C. The strong magnetic fields of Jupiter and Saturn attracting more material
    D. Uranus/Neptune formed too slow and ran out of time before the disk dissipated

15. A tsunami triggered by an earthquake off Alaska's coast takes how long to reach Kaui, Hawaii?
    A. 30 min
    B. 1 hour
    C. 3 hours
    D. 6 hours
16. A hypothetical planet whose orbit has a semi-major axis 10 times that of the Earth's orbit around the Sun will have a sidereal period of about which of the following?
    A. 10 Earth years
    B. 32 Earth years
    C. 100 Earth years
    D. 167 Earth years
17. If the wind is blowing from south to north at 45°N in the North Pacific Ocean, what direction is the net volumetric transport of the water?
    A. Towards the northeast
    B. Towards the east
    C. Towards the southeast
    D. Towards the west
18. Which of the following is NOT a method of locating the bodies of mass of objects in the universe that are not otherwise observable?
    A. Astrometry
    B. Gravitational Lensing
    C. Jahn-Teller Distortion
    D. Sunyaev–Zeldovich effect
19. Which of the following objects do not contain an existing or theorized compact star?
    A. Wolf–Rayet stars
    B. Quark Stars
    C. Thorne–Żytkow objects
    D. Blitzars
20. Which of the following correctly orders these minerals on the continuous series from highest crystallization to lowest crystallization temperature?
    A. Anorthite, Bytownite, Labradorite, Andesine, Oligoclase, Albite
    B. Oligoclase, Albite, Labradorite, Andesine, Anorthite, Bytonite
    C. Labradorite, Oligoclase, Albite, Andesine, Bytonite, Anorthite
    D. Bytownite, Oligoclase, Albite, Andesine, Anorthite, Labradorite
21. In the northern hemisphere, which direction do mid-latitude cyclones and anticyclones rotate, respectively?
    A. counterclockwise, clockwise
    B. clockwise, counterclockwise
    C. clockwise, clockwise
    D. counterclockwise, counterclockwise
22. A piece of ocean crust that is uplifted onto the continents during orogeny is known as?
    A. Tektite
    B. Oolite
    C. Ortholite
    D. Ophiolite
23. A sample started with 2.0 grams of C-14, which has a half-life of 5730 years. How many grams are left after 11460 years?
    A. 0.25g
    B. 0.5g
    C. 1.0g
    D. 2.0g
24. The E horizon typically lies between which two horizons?
    A. A, B horizons
    B. O, A horizons
    C. O, B horizons
    D. B, C horizons
25. On the Bowen's Reaction Series discontinuous series, which mineral has the highest crystallization temperature?
    A. Amphibole
    B. Pyroxene
    C. Olivine
    D. Biotite Mica
26. Cold air at the surface typically corresponds to ____ while cold air aloft corresponds to ____?
    A. High pressure, High pressure
    B. High Pressure, Low pressure
    C. Low Pressure, High pressure
    D. Low pressure, Low pressure
27. Which of the following is not true about Lodgement Till?
    A. it is from glacial origin
    B. It is deposited when the ice melts
    C. It is not sorted well
    D. It is typically unbedded

28. Shallow-water waves are in a depth that is less than which of the following?
    A. 1 wavelength
    B. 1/2 wavelength
    C. 1/10 wavelength
    D. 1/20 wavelength

29. Which of the following is not true about an area of Karst Topography?
    A. It has many caves, sinkholes and underground streams
    B. It has plentiful rainfall
    C. It has many surface streams
    D. It is underlain by calcium carbonate rich rock

30. What is the chemical formula of quartz?
    A. SiO2
    B. C10H16O
    C. KAlSi3O8
    D. NaAlSi3O8

5 Miscellaneous

1. Which of the following does not follow from the Axiom of Completeness (in reals)?
   A. Nested Interval Property
   B. Cauchy Criterion
   C. Bolzano-Weierstrass Theorem
   D. Algebraic Limit Theorems
2. How many permutations of APPARENT have the pairs of A's and P's together (AA and SS)?
   A. 120
   B. 300
   C. 600
   D. 720
3. The normal distribution is determined by which of the following quantities?
   A. Mean
   B. Variance
   C. Both of these
   D. Neither of these
4. Triangle ABC has perimeter 16 and area 20. If AB has length 6, then the C-exradius of ABC has what length?
   A. 2.5
   B. 8
   C. 10
   D. 12
5. Which of the following sorting algorithms has the best worst-case time complexity?
   A. Quicksort
   B. Insertion sort
   C. Timsort
   D. Bogosort
6. Fermat's Christmas Theorem states that any odd prime number can be expressed as the sum of two squares if and only if it is congruent to 1 in which modulus?
   A. 3
   B. 4
   C. 6
   D. 10
7. The Catalan numbers do NOT appear as answers to which of the following counting problems?
   A. The number of expressions consisting of correctly matched pairs of parentheses
   B. The number of paths from (0,0) to (n,n) which do not cross the main diagonal between those two points
   C. The number of different ways to cut a convex polygon with n+2 sides into n triangles
   D. The number of sequences that begin with 1 and increase by either 0 or 1
8. Which of the following computational problems are not NP-complete?
   A. In graph theory, finding a path in an undirected graph that visits each vertex exactly once
   B. In number theory, approximating the number of primes below a certain integer
   C. In number theory, finding the prime factorization of an integer
   D. In computer science, deciding if it is possible to find a subset of a set of integers that sums to a given value
9. Which of the following does not match the correct computer scientist with one of their fields of research?
   A. Donald Knuth, machine learning and artificial intelligence
   B. Richard Hamming, error correcting codes
   C. Edsger Dijkstra, graph theory
   D. Adi Shamir, cryptography
10. Which of the following symbols cannot be used to redirect input or output in bash?
    A. $>$, the greater than symbol
    B. $<$, the less than symbol
    C. \$, the dollar sign
    D. $|$, the vertical bar
11. Which of the following data structures does not support insertion, on average, in constant time?
    A. Linked List
    B. Binary Tree
    C. Hash Table
    D. Stack

12. Two groups G and H are isomorphic if which of the following are true?
    A. A bijection exists between them
    B. An injection exists between them
    C. A bijection which preserves group action exists between them
    D. A surjection which preserves group action exists between them
13. The Racetrack Principle, in rough terms, states that if two horses Frank and Greg start a race at the same time from the same place, and Frank always runs faster than Greg, then Frank will win. Which of the following does it directly result from?
    A. Intermediate Value Theorem
    B. Mean Value Theorem
    C. Definition of Continuity
    D. Archimedean Principle
14. Which of the following is closest to the rate the sum of the reciprocals of primes grows?
    A. It converges, so eventually zero
    B. $\log(\log n)$
    C. $\log(n)$
    D. $n^{-1/2}$
15. Let a be the number of bytes it takes to store a double variable in Java. Let b be the number of bits it takes to store a boolean variable in Java. What is a*b?
    A. 8
    B. 16
    C. 32
    D. 64
16. Klebb tosses a fair coin with sides labelled 0 and 1 then rolls a die. What is the probability that the die roll has the same parity as the coin flip?
    A. 1/6
    B. 1/3
    C. 1/2
    D. 2/3
17. Fishy is trying to create a Python program that prints true when n is even and false when n is odd. Which of the following is an incorrect implementation of Fishy's program?
    A. print(n%(3-=1)==0)
    B. print(True if n%2==0 else False)
    C. print([True,False][n%2])
    D. print(0==n%(True+True))
18. Which of the following is NOT named after Leonhard Euler?
    A. In a polyhedron with V vertices, E edges, and F faces, $V - E + F = 2$.
    B. The compressive load at which a column will suddenly buckle
    C. The number of relatively prime integers less than a given integer
    D. The reciprocal of the arithmetic mean of 1 and the square root of 2
19. Let SHA-388 be a hashing function that produces 388 bits in its digest. According to the Birthday Theorem, let n be the number of bits of security this hashing function has. What is the nearest integer to n?
    A. 14
    B. 20
    C. 194
    D. 388
20. AC goes to birdso.org and loads the page. Which of the following HTTP request headers tells birdso.org about the details of AC's browser?
    A. User-Agent
    B. Referer
    C. Browser
    D. Browser-Refer
21. Which of the following is an interpreted language?
    A. Python
    B. Java
    C. Kotlin
    D. Fortran
22. A polynomial P with real coefficients has three distinct complex roots r, s, and t. Which of the following statements CANNOT be true?
    A. The degree of P is greater than 8
    B. r, s, and t are all real
    C. r, s, and t all have imaginary parts with different magnitudes
    D. The sum r + s + t is real
23. Triangle DAB is similar to triangle TIE. If $DA = 5$, $AB = 7$, and $IE = 11$, then which of the following is closest to the length of TI?
    A. 7
    B. 8
    C. 13
    D. 15

24. Trapezoid $LAME$ is cyclic (that is, $LAME$ can be inscribed inside a circle such that all of its vertices touch the circle). Let the intersection of diagonals LM and AE be I. If angle LAE has measure 22 degrees, then what is the measure of angle AIM in degrees?
    A. 22
    B. 68
    C. 112
    D. 136
25. How many (positive) factors does 2022 have?
    A. 8
    B. 7
    C. 4
    D. 3
26. Compute the cross product of the following vectors: $\langle 2, 6, -1\rangle$ and $\langle -2, -1, -1\rangle$.
    A. $\langle -7, 4, 10\rangle$
    B. $\langle -4, -6, 1\rangle$
    C. $\langle 2, 0, -1\rangle$
    D. $\langle 0, 5, -2\rangle$
27. Which of the following is the supremum of the set of numbers in the interval [1, 3)?
    A. 1
    B. 2
    C. 3
    D. None of these
28. Which of the following rings is not a field?
    A. $\mathbb{Z}$, the set of integers over addition and multiplication
    B. $\mathbb{Z}/p\mathbb{Z}$, the set of integers modulo p over addition and multiplication, where p is prime
    C. $\mathbb{Q}$, the set of rationals over addition and multiplication
    D. $\mathbb{C}$, the set of complex numbers over addition and multiplication
29. The prime number theorem states that the number of primes less than a number N approaches which of the following quantities?
    A. $1/\log N$
    B. $N/\log(\log N)$
    C. $N/\log N$
    D. $N \log N$
30. A real-valued function is said to be continuous at a point p if which of the following is true?
    A. The limit of the function at p is equal to the function evaluated at p
    B. The limit of the function at p exists
    C. The limit of the function at p exists and the function can be evaluated at p
    D. The function can be evaluated at p