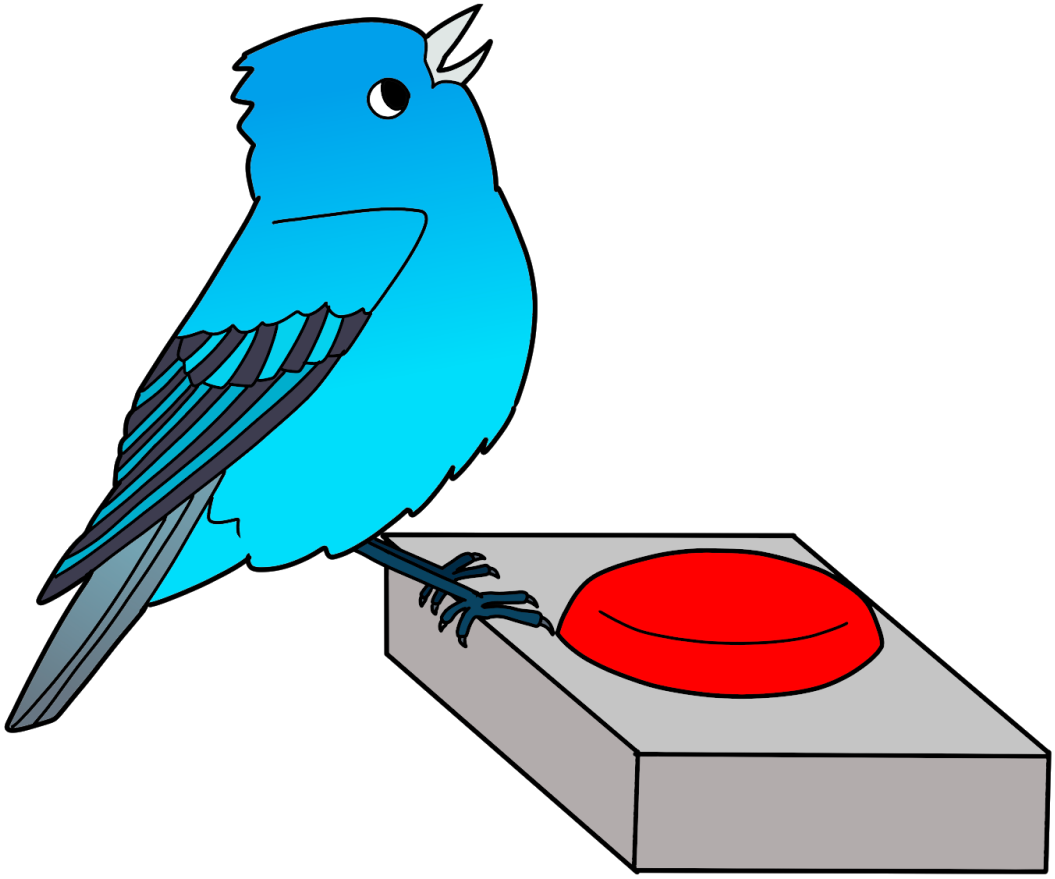
BirdSO Science Quiz Bowl Written Exam – Division C

March 7 – March 13, 2021



Instructions:

- No notes, calculators, Ornithology field guides, etc.
- Problems are divided into categories:
- Assume problems occur at STP and that g=9.8 m/s² unless otherwise stated.

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PHYSICS

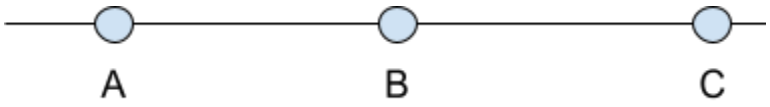
1. A hot air balloon is rising at a constant velocity of 5.00 m/s. When it reaches a height of 40.0 m, a sandbag is dropped from the balloon. How many seconds will it take the sandbag to hit the ground after it has been dropped?
2. Tiffany is bungee jumping off a 532. m cliff. The instant she steps off the platform, she also lets out a yelp, which echoes off the surface of the ground beneath her. Given that the speed of sound is 340. m/s, how many seconds after she jumps off the platform should she hear her echo?
3. A wheel rotates with a constant 5 rad/s^2 angular acceleration. In a 3.00 second interval the wheel rotates through an angle of 60.0 radians. What was the initial angular velocity of the wheel at the start of this interval?
4. A 40. g air hockey puck is traveling towards Emma, who knocks the puck in the opposite direction by applying a force of 3.0 N over a 0.050 s duration. Given that the puck had an instantaneous velocity of 1.00 m/s just before Emma hit it and that the coefficient of friction between the puck and the air hockey table is 0.10, how far will the puck travel across the table before it comes to rest?
5. Daniel is driving on an icy road when he approaches a banked curve of radius R while he is traveling at velocity v. Which of the following expressions gives the angle at which the curve must be banked such that Daniel can safely make the turn, even if his wheels don't get any traction?
6. Anna grabs the end of a 14 m massless rope hanging from the ceiling that makes an angle of 45 deg wrt to the vertical and jumps, swinging down then up across the room towards her friend Emily. When Anna reaches Emily, her rope makes an angle of 30 degrees with the vertical. What speed is Anna traveling when she reaches Emily?
7. Tiffany fires a 50. g arrow with her bow straight up and finds that it requires 10.0 s to hit the ground. How much potential energy, in joules, was transferred from Tiffany's bowstring into her arrow?
8. A ball of radius R starts from rest and rolls without slipping down a ramp, covering a vertical distance h in the process. Derive an expression for the velocity of the center of mass of this ball.
    a. sqrt(gh/4)
    b. sqrt(5gh/4)
    c. sqrt(10gh/7)
    d. sqrt(11gh/7)
9. Select all of the following properties that are possessed by ideal fluids.
    a. Infinite surface tension

    b. Constant density
    c. Compressible
    d. Finite bulk modulus
10. A bottle of water is filled to a height h. A pinhole of area A is then punched into the bottom of the bottle. Given that the air pressure of the air above the water surface in the bottle is p, what is the volume flow rate of water out of the hole in the bottom?
11. Select all of the following dimensionless numbers that are incorrectly matched with their description.
    a. Grashof number: ratio of buoyant to viscous forces
    b. Nusselt number: ratio of convective to conductive heat transfer
    c. Rayleigh number: ratio of inertial to viscous forces
    d. Reynolds number: ratio of buoyant to viscous forces
12. Select all of the following variables upon which the speed of sound through an ideal gas depends.
    a. Molar mass of gas
    b. Temperature
    c. Constant volume heat capacity of the gas
    d. Constant pressure heat capacity of the gas
13. Select all of the following statements that are true of electric field lines.
    a. It is perpendicular to the electric field at all points
    b. They begin at positive charges and end at negative charges
    c. They do not exist if the electric field is uniform
    d. They never intersect with magnetic field lines
14. Which of the following quantities is minimized in an ideal resonating LC circuit?
    a. Resistance
    b. Capacitance
    c. Reactance
    d. Impedance
15. Select all of the following properties possessed by an ideal op-amp.
    a. Zero noise
    b. Zero output impedance
    c. Infinite open-loop gain
    d. Zero input current
16. What particle is represented as a wavy line on Feynman diagrams?
    a. Photons
    b. Electrons

    c. Neutrons
    d. Protons
17. Select all of the following particles that have half-integer spin.
    a. Electrons
    b. Muons
    c. Tauons
    d. Neutrinos
18. The Michelson-Morley experiment attempted to verify the existence of the luminiferous ether using which of the following experimental devices?
    a. Cloud chamber
    b. Bubble chamber
    c. Torsion balance
    d. Interferometer
19. What set of equations derived from the Einstein field equations may be used to calculate the density parameter of the universe?
    a. Klein-Gordon equation
    b. Friedmann equations
    c. Onsager reciprocal relations
    d. Maxwell's equations
20. A point-source emits a sound wave with an intensity of 20W. If a person stands 5 meters away from the point-source, how loud is the sound to them, in decibels?
    a. 102dB
    b. 104dB
    c. 106dB
    d. 108dB
21. The key A4 (440Hz) is played on the piano. Which of the following notes will also sound as a result of sympathetic resonance?
    a. A3
    b. E3
    c. C4
    d. B4
22. A ball, originally at the top of a ramp, drops down x centimeters before the ramp curves up and launches the ball up in the air. What is the maximum range of the ball in terms of x centimeters?
    a. 2x
    b. 3x
    c. 4x

d. 5x

23. Assuming masses stay constant, how would the tidal force between two objects change if the distance was halved?
    a. 2 times stronger
    b. 4 times stronger
    c. 8 times stronger
    d. 16 times stronger
24. Which of the following colors of noise has a frequency density proportional to $\frac{1}{f^2}$?
    a. White
    b. Brownian
    c. Violet
    d. Pink
25. The surface tension constant Gamma depends is inversely proportional to _____ and directly proportional to _____?
    a. Force, Length
    b. Acceleration, length
    c. Length, acceleration
    d. Length, force
26. At what angle is it ideal to launch a cannonball off a cliff in order to get the maximum range?
    a. 0 degrees
    b. 45 degrees
    c. between 0 and 45 degrees
    d. Between 45 and 90 degrees
27. The time constant tau represents the time required for the charge to increase from 0 to what percent of its maximum equilibrium value?
    a. 37.7
    b. 51.6
    c. 63.2
    d. 78.4
28. Consider three charged objects lying on a flat plane as shown in the diagram below (not drawn to scale). Object A, has a charge of 11.1 μC, and lies 3 meters away from object B. Object B has a charge of 4.5 μC, and lies 4 meters away from object C. Object C has a charge of 8.2 μC. Which of the following statements is true about the net forces on each of these objects? Ignore the gravitational forces and assume the objects act as point charges.



a. $F_A = F_B = F_C$
b. $F_A < F_B < F_C$
c. $F_A < F_B > F_C$
d. $F_A > F_B = F_C$

29. Andrew is riding on a Ferris wheel, when he wonders about how much he weighs (for some reason, he has a scale on him). However, he realizes that his weight at the top of the Ferris wheel is different from his weight at the bottom. Why does this happen?
    a. The normal force is acting on Andrew in the same direction as the force due to gravity at the bottom of the Ferris wheel, but it is acting in the opposite direction at the top of the Ferris wheel.
    b. The normal force on Andrew is acting in the opposite direction as the force due to gravity at the bottom of the Ferris wheel, but it is acting in the same direction at the top of the Ferris wheel.
    c. The normal force is acting in the opposite direction as the force due to gravity at the top and bottom of the Ferris wheel, but the normal force is greater in magnitude than the force due to gravity at the top of the Ferris wheel.
    d. The normal force is acting in the opposite direction as the force due to gravity at the top and bottom of the Ferris wheel, but the normal force is greater in magnitude than the force due to gravity at the bottom of the Ferris wheel.
30. A spring with a natural length of 32 cm and a spring constant of 211 N/m is hung vertically with a 15 kg mass attached at the end. Assuming the spring's mass is negligible, what will be the final length of the spring when it reaches equilibrium? Use g=10 m/s^2.
    a. 90cm
    b. 103cm
    c. 138cm
    d. 188cm
31. Assuming the spring-mass system in the question above is ideal and free of friction, which of the following would best describe the system?
    a. Undamped
    b. Underdamped

c. Overdamped
d. Pseudodamped

32. A compact disc has a radius of 8 cm. If the disc rotates about its central axis with an angular speed of 8 rev/s, what is the linear speed of a point on the rim of the disc?
    a. 1.0 m/s
    b. 2.0 m/s
    c. 4.0 m/s
    d. 8.0 m/s
33. A block hangs from a string which is suspended from a horizontal surface. When the string is plucked, it vibrates, producing a sound. The frequency of the sound does not depend on which of the following?
    a. The linear density of the string
    b. The length of the string
    c. The mass of the block
    d. The material of the string
34. Aidan looks into a convex mirror. Which of the following could describe the image that is created?
    a. Real
    b. Virtual
    c. Upright
    d. Inverted

CHEMISTRY

1. Select all of the following choices that correctly order the ionization energies of the species listed.
    a. O > N > C > B
    b. Mn > Cr > V > Ti
    c. Zn^3+ > Zn^2+ > Zn+ > Zn
    d. C > P > B > Si
2. Select all of the following choices that list an allowed set of quantum numbers.
    a. n=1, l=0, ml=0, ms=+½
    b. n=2, l=1, ml=-1, ms=+½
    c. n=2, l=2, ml=0, ms=-½
    d. n=1, l=0, ml=0, ms=-½
3. How many radial nodes does a 3d orbital have?
    a. 0
    b. 1
    c. 2
    d. 3
4. Select all of the following unit cells with a packing efficiency of 74.04%.
    a. Face-centered cubic
    b. Simple cubic
    c. Body-centered cubic
    d. Diamond cubic
5. Select all of the following compounds that have linear VSEPR geometry.
    a. HCN
    b. CO2
    c. O3
    d. I3-
6. Select all of the following chemical species with a bond order of 0.5.
    a. He^{2+}
    b. H^{2-}
    c. H^{2+}
    d. He^{2}
7. Select all of the following compounds that are correctly matched with their symmetry group.
    a. H2O; C2v
    b. PCl5; D3h
    c. Cyclohexane chair conformation; D3d
    d. H2O2; C2

8. 10. g of water at 27 C is mixed with 40. g of water at 87 C. What is the final temperature of this mixture?
    a. 57 C
    b. 75 C
    c. 39 C
    d. 114 C
9. Which of the following is not one of the laws of thermodynamics?
    a. If two systems are both in thermal equilibrium with a third system then they are in thermal equilibrium with each other
    b. At absolute zero systems have constant entropy
    c. Systems tend towards the state of greatest entropy
    d. Heat always flows from regions of high temperature to regions of low temperature
10. Select all of the following choices that list a pair of thermodynamic conjugate variables.
    a. Pressure and volume
    b. Temperature and entropy
    c. Chemical potential and particle number
    d. Gibbs free energy and Helmholtz free energy
11. When the following chemical reaction is balanced, what is the coefficient for I-?

$$IO^{3-} + I^{-} + H^{+} \rightarrow I_2 + H_2O$$

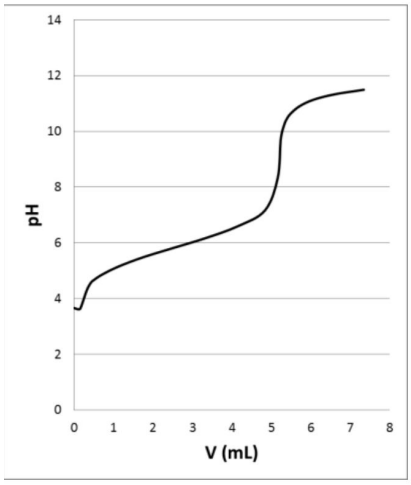
    a. 3
    b. 5
    c. 6
    d. 1
12. 88.2 g of a certain hydrocarbon is completely combusted in oxygen, yielding 134 L of CO_2 gas and 144 mL of H_2O. Which of the following is the chemical formula of this hydrocarbon?
    a. C_3H_8
    b. C_2H_2
    c. C_3H_6
    d. C_4H_8
13. Which of the following indicators would be most appropriate for the titration of acetic acid (pKa=3.75) with sodium hydroxide?
    a. Phenolpthalein (pH range 8.2-10.0)
    b. Methyl orange (3.2-4.4)
    c. BTB (6.0-7.6)
    d. Methyl red (4.8-6.0)

14. Select all of the following observations that one would expect to make during the electrolysis of KI.
    a. Solution at the anode turns yellow-brown
    b. Gas evolution at the anode
    c. Dropping phenolphthalein in the cathode turns the solution blue
    d. Gas evolution at the cathode
15. Which of the following techniques would be most appropriate for determining the functional groups present in a given compound?
    a. Raman spectroscopy
    b. Mass spectrometry
    c. NMR spectroscopy
    d. IR spectroscopy
16. A sample of 1-bromohexane is added to a separatory funnel along with diethyl ether and water. Since diethyl ether and water are immiscible, the mixture separates into two layers. Select all of the following statements that are true.
    a. The bromohexane is in the top layer
    b. The bromohexane is in the bottom layer
    c. The top layer corresponds to the aqueous layer
    d. The top layer corresponds to the ether layer
17. How many structural isomers of pentane are there?
    a. 2
    b. 3
    c. 4
    d. 5
18. Select all of the following conditions that would favor an SN2 reaction mechanism.
    a. Weak nucleophile
    b. Polar aprotic solvent
    c. Tertiary substrate
    d. High temperature
19. Which of the following best describes the role of H_2SO_4 in a Fischer esterification?
    a. Reactant
    b. Product
    c. Catalyst
    d. Intermediate
20. Select all of the following positions on pyridine that would be expected to react with nucleophiles.
    a. 1

b. 2
c. 3
d. 4

21. What chemical can be used as a tracer to find the speed of deep sea currents?
    a. DDT
    b. Chlorofluorocarbons
    c. Cadmium bromide
    d. Magnesium hydroxide
22. Which of the following trace elements are the most abundant in the seawater
    a. aluminum
    b. phosphorus
    c. iodine
    d. iron
23. In an exothermic reaction, will the transition state more closely resemble the reactants or the products?
    a. The reactants
    b. The products
    c. Neither
    d. A structure in-between the reactants and products
24. What are degenerate orbitals?
    a. Orbitals that are paramagnetic rather than diamagnetic.
    b. Orbitals that possess more anti-bonding electrons than bonding electrons.
    c. Orbitals have an equal probability of being occupied by an electron.
    d. Orbitals that decrease in energy during intermolecular interactions.
25. Which element has a partially filled atomic orbital?
    a. Be
    b. Zn
    c. Ne
    d. Ag
26. What is the ligand of the coordination compound $[Fe(NH_3)_6]^{3+}$?
    a. Fe
    b. NH_3
    c. $(NH_3)_6$
    d. $[Fe(NH_3)_6]^{3+}$
27. According to the Crystal Field Theory, why do the t_{2g} set orbitals in an octahedral field experience a decrease in energy?

a. These orbitals lie on the *x* and *y* axes of the octahedron, and therefore experience lower energy from increased proximity to the nucleus.
b. These orbitals lie in-between the ligand axes, and therefore experience minimum repulsion with the ligand orbitals.
c. These orbitals lie on the *x* and *y* axes an equal distance from the e_g set away from the barycenter, and this degeneracy lowers their energy to be equal to that of the e_g set.
d. These orbitals are the lower set of orbitals in an octahedral structure, and therefore decrease in energy to become more stable in comparison to the upper set of orbitals.

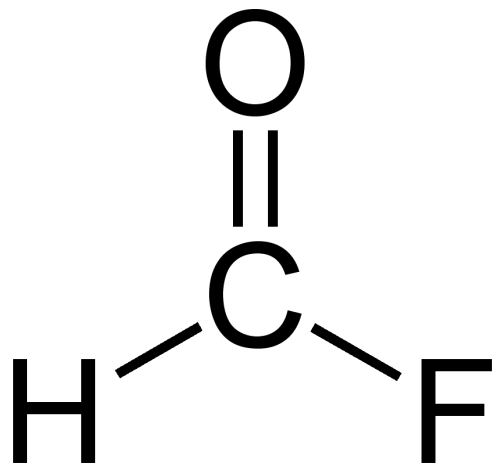
28. Which of the following statements is true?
    a. Bond dissociation energies vary according to the compound and not the element.
    b. Bond dissociation energies increase down a column of the periodic table.
    c. Bond dissociation energies decrease down a column of the periodic table.
    d. There is no predictable trend for bond dissociation energies.
29. As potassium iodide is stirred into water, the compound dissolves endothermically. Which of the following best helps to explain why the process is thermodynamically favorable at 25°C?
    a. Dissolving the salt decreases the enthalpy of the system.
    b. Dissolving the salt increases the entropy of the system.
    c. All endothermic processes are thermodynamically favorable.
    d. Stirring the solution adds the energy needed to drive an endothermic process.
30. 

    The titration curve above represents that of an unknown acid that has been titrated with a KOH. Which of the following is the kPa of the unknown acid?

2.2
4.4
5.7
9.1

31. Ultraviolet and visible radiation affect which of the following?
    a. Core electrons
    b. Valence electrons
    c. Nuclear spin
    d. Molecular rotations
32. If cell length is held constant, a Beer's Law plot of a given analyte will result in a linear relationship between
    a. Concentration and wavelength
    b. Transmission intensity and concentration
    c. Absorbance and concentration
    d. Transmission intensity and wavelength

Given the structure of fluoroformaldehyde below:



33. What is the electron domain geometry of the carbon atom in fluoroformaldehyde?
    a. Linear
    b. Trigonal planar
    c. Tetrahedral
    d. Trigonal bipyramidal
34. What is the molecular geometry of the carbon atom in fluoroformaldehyde?
    a. Bent
    b. Trigonal pyramidal
    c. Trigonal planar

d. T-shaped

35. Which of the following statements about spin configuration is true?
    a. 4d and 5d complexes tend to favor a high-spin configuration due to atomic size.
    b. If the energy difference between the upper set d orbitals and the lower set is greater than the energy associated with the energy repulsion, then a high-spin configuration is favored.
    c. 3d metals follow a high-spin configuration, so as electrons are placed in the lowest-energy orbitals available, each degenerate t_2 orbital is occupied by a single electron rather than pairs to minimize repulsion.
    d. The lower the metal's oxidation state the larger the CFSE and therefore the greater the tendency for the complex to be low-spin.

BIOLOGY

1. Select all of the following macromolecule types that are incorrectly matched with a type of chemical bond that would be found in them.
    a. Carbohydrates; phosphodiester bond
    b. Lipids; ester linkage
    c. Proteins; peptide bond
    d. Nucleic acids; glycosidic linkage
2. Which of the following explains why long chains of glutamate will not form alpha helices when at a pH of 7?
    a. Unfavorable steric interactions between R groups
    b. Repulsion between negative charges of carboxyl groups
    c. Repulsion between positive charges on amino groups
    d. Inability for glutamate to form a sufficient number of hydrogen bonds
3. Which of the following is not a step in the procedure for PCR?
    a. Extension
    b. Annealing
    c. Denaturation
    d. Duplication
4. Select all of the following that are correctly matched with their function.
    a. Smooth ER: Protein production
    b. Mitochondria: Powerhouse of the cell
    c. Nucleus: DNA Storage
    d. Flagella: Movement
5. Select all of the following choices that are common second messengers.
    a. cAMP
    b. IP3
    c. Ca2+
    d. DAG
6. What is the coefficient of relatedness between first cousins?
    a. 0.125
    b. 0.0625
    c. 0.25
    d. 0.09375
7. Select all of the following that are functions of auxin.
    a. Inducing apical dominance
    b. Regeneration of damaged vascular tissues

    c. Root initiation
    d. Fruit growth
8. Which of the following is not part of the ethylene triple response in plants?
    a. Shortened hypocotyl
    b. Thickened hypocotyl
    c. Lengthened roots
    d. Exaggerated apical hook
9. What layer of the epidermis is found primarily in the palms of hands and soles of feet?
    a. Stratum corneum
    b. Stratum lucidum
    c. Stratum basale
    d. Stratum granulosum
10. What muscle is responsible for the turning and nodding of the head?
    a. Scalene muscles
    b. Mylohyoid muscle
    c. Sternocleidomastoid muscle
    d. Longus colli muscle
11. Which of the following compounds is the primary component of pulmonary surfactant?
    a. DPPC
    b. Collectins
    c. Cholesterol
    d. Mucus
12. Select all of the following blood vessels that carry deoxygenated blood.
    a. Pulmonary artery
    b. Pulmonary vein
    c. Hepatic portal vein
    d. Hepatic artery
13. Which of the following ecological principles states that two species cannot occupy the same niche?
    a. Dollo's law of irreversibility
    b. Gloger's rule
    c. Competitive exclusion principle
    d. Eichler's rule
14. What type of survivorship curve do most marine invertebrates follow?
    a. Type I

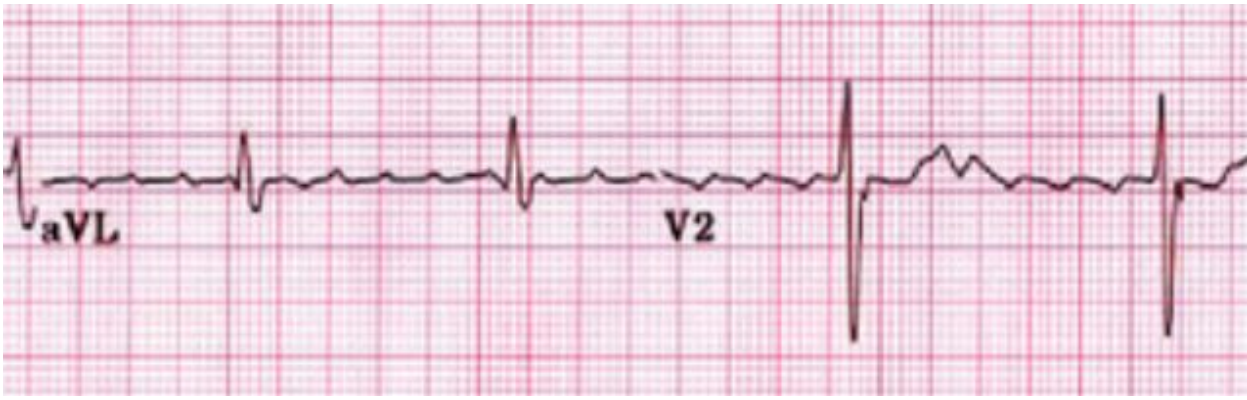
b. Type II
c. Type III
d. Type IV

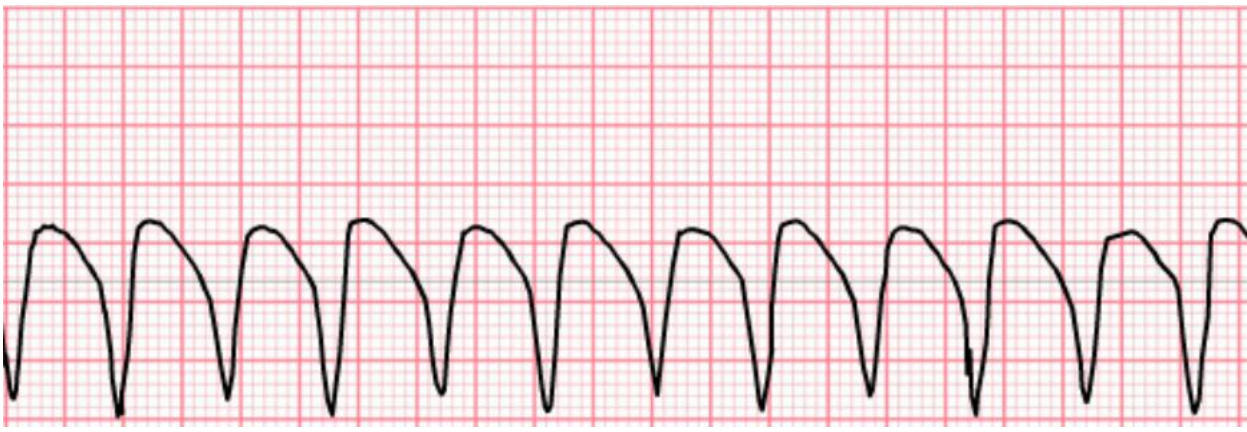
15. Which of the following scientists is known for helping develop the theory of punctuated equilibrium?
    a. Charles Darwin
    b. Stephen Jay Gould
    c. Carolus Linnaeus
    d. James Hutton
16. What genus of bird-like dinosaurs marks the transition between non-avian feathered dinosaurs and modern birds?
    a. Archaeopteryx
    b. Titanis
    c. Pterodactyl
    d. Oviraptoridae
17. Which of the following terms best describe Greylag goose egg rolling?
    a. Agonistic behavior
    b. Fixed action pattern
    c. Imprinting
    d. Bruce effect
18. To what genus of bacteria does the causitive agent of anthrax belong?
    a. Escherichia
    b. Pseudomonas
    c. Staphylococcus
    d. Bacillus
19. Which of the following is not a criterion used in establishing a causal relationship in public health research?
    a. Reproducibility
    b. Falsifiable
    c. Specificity
    d. Plausibility
20. Which subclass of osteichthyes contains ray-finned bony fish such as tuna and salmon?
    a. Sarcopterygii
    b. Actinopterygii
    c. Acanthodii
    d. Elasmobranchii

21. Which of the following features is not present in bivalves but is present in other molluscs?
    a. Radula
    b. Siphon
    c. Foot
    d. Mantle
22. Which of the following is NOT an invasive species?
    a. Asian carp
    b. Zebra mussel
    c. Lionfish
    d. Giant clam
23. Which mechanism of genetic exchange among bacteria forms new, hybrid genomes?
    a. Transformation
    b. Conjugation
    c. Recombination
    d. Translation
24. What unique structure is primarily used in the cell division of green algae?
    a. chloroplast
    b. phycoplast
    c. flagella
    d. Hyphae
25. Which of the following is not classified as an agranulocyte?
    a. Neutrophil
    b. Basophil
    c. Eosinophil
    d. Killer T Cells
26. Consider a plant that lives in a hot and dry environment. What is true about this plant?
    a. If the plant did not adapt to its environment, its stomata would open less frequently to prevent more water from transpiring and the resulting dehydration.
    b. This plant uses PEP carboxylase to fix carbon dioxide that will be used in the Calvin cycle to reduce the dependence on oxygenase.
    c. This plant will have adapted to contain rubisco in both bundle sheath cells and mesophyll cells to aid with oxygenation.

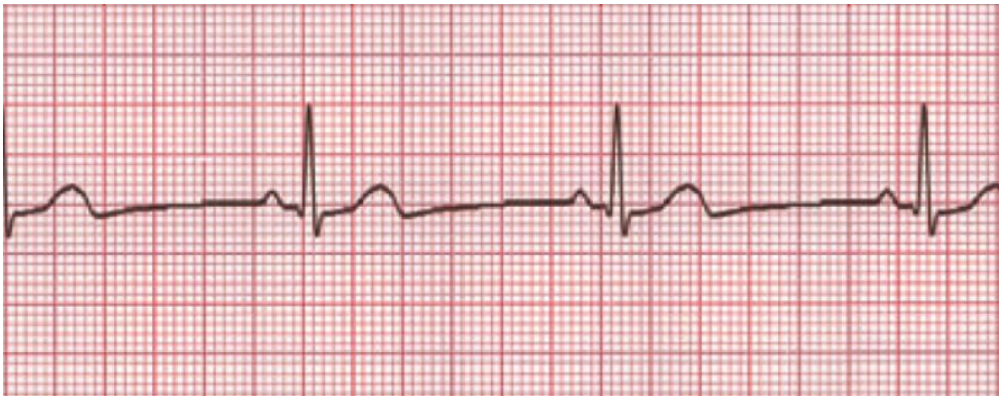
d. When this plant fixes carbon dioxide, it adds a carbon to form a 3-carbon compound.

27. Insects lack lungs. Instead, they "breathe" through which of the following?
    a. Air sacs
    b. Gills
    c. Spiracles
    d. Tubules
28. If the anterior pituitary gland was damaged and could not properly function, which of the following may directly result?
    a. The kidneys' production of ADH would be inhibited, causing increased dehydration and urine production.
    b. If the person is currently breastfeeding, the production of milk would halt and permanently stop.
    c. The production of estrogen would cease, interrupting the menstrual cycle and release of an egg from the ovaries.
    d. The body would not properly respond to increased levels of sugar in the bloodstream, and cell uptake of sugar would be interrupted.
29. Which of the following statements is *not* true about viral genetic material?
    a. Negative-sense viruses must possess an RNA-dependent RNA polymerase during replication in a host cell in order to translate their genome to a positive-sense strand to allow for translation.
    b. Most viruses that have DNA as their primary genetic material are double stranded viruses.
    c. Positive-sense genomes must possess a DNA-dependent DNA polymerase during replication in a host cell in order to translate their genome to a negative-sense strand to allow for translation.
    d. Some viruses are negative-sense and possess ssRNA as well, such as the influenza viruses.
30. It would be appropriate to use a defibrillator for a patient who produces which of the EKGs below?

a. 

b. 

c. 

d. 

31. The Cordyceps fungi is a type of parasite that parasitizes a wide variety of arthropods. Which of the following best describes how it reproduces?
    a. Binary fission
    b. Spores

c. Parthenogenesis
d. Hermaphroditism

32. You are talking to your biologist friend, who mentions that they are trying to learn more about a mysterious bacterium they have discovered. In order to learn more about the bacterium, your friend runs two procedures on the bacteria sample, first staining them with crystal violet, then staining them with safranin. After the first procedure, the cells do not change color, but after the second procedure, the cells are stained pink. What can you assume about this bacterium?
    a. It has a cell wall that does not contain peptidoglycan, but does contain various lipopolysaccharides.
    b. It has a single cell wall and a single cell membrane which cannot retain the crystal violet color.
    c. It has a thin peptidoglycan cell wall as well as two separate membranes surrounding this cell wall.
    d. It has a thick peptidoglycan layer as well as peptidoglycan chains and various lipoids.
33. The myocytes in your gut develop from which germ layer?
    a. Endoderm
    b. Mesoderm
    c. Ectoderm
    d. Hypnoderm
34. Some species of salamanders produce eggs that begin to divide in the presence of a sperm cell but without the genetic material of the sperm cell. This is an example of:
    a. Gynogenesis
    b. Kleptogenesis
    c. Androgenesis
    d. Hybridogenesis
35. Out of the following, which evolved first?
    a. Amniotic egg
    b. Oviparity
    c. Ovoviviparity
    d. Viviparity

EARTH AND SPACE

1. What rock has a Mohs hardness of 8?
    a. Corundum
    b. Quartz
    c. Topaz
    d. Orthoclase
2. A rock sample can be scratched with a knife but not with a penny. Select all of the following that could correspond to the identity of this sample.
    a. Anthracite
    b. Calcite
    c. Apatite
    d. Galena
3. Select all of the following principles of relative dating that are incorrectly matched with its description.
    a. Superposition: Layers at the top are younger than layers at the bottom
    b. Lateral continuity: Sediment forms in layers unless it thins to nothing or terminates
    c. Faunal Succession: If two layers have the same fossils the layers must be of the same age
    d. Inclusion: If a rock contains fragments of another rock than the rock that includes the fragments is older than the included fragments
4. Select all of the following atmospheric layers that are adjacent to the stratosphere.
    a. Mesosphere
    b. Thermosphere
    c. Exosphere
    d. Troposphere
5. What wind patterns are responsible for the formation of cyclones and anti-cyclones?
    a. Kelvin-Helmholtz instability
    b. Madden-Julian oscillation
    c. Walker circulation
    d. Rossby waves
6. Which of the following best characterizes the stability of an air mass if the environmental lapse rate is greater than the dry adiabatic lapse rate?
    a. Absolute stability
    b. Absolute instability
    c. Dynamic instability

    d. Neutral stability
7. Select all of the following that are more abundant in river water than in ocean water.
    a. Silica
    b. Calcium
    c. Sodium
    d. Bicarbonate
8. In which of the following ecosystems would you find shredders and collectors?
    a. Forests
    b. Tide pools
    c. Streams
    d. Coral reefs
9. Which of the following statements is not true of manganese nodules?
    a. They are of economic interest because they contain valuable metals
    b. They require a nucleus such as a rock or bone fragment to form
    c. They are classified as hydrogenous sediment
    d. They must remain buried under sediment to grow
10. Under ideal conditions in the Northern Hemisphere, Ekman transport causes surface currents to form what angle with the wind?
    a. 45 degrees right of the wind
    b. 45 degrees left of the wind
    c. 90 degrees right of the wind
    d. 90 degrees left of the wind
11. What Köppen climate class corresponds to boreal climates?
    a. Am
    b. Af
    c. Csa
    d. Dfc
12. For which geologic period does the Burgess shale serve as an important Lagerstätten?
    a. Cambrian
    b. Devonian
    c. Ordovician
    d. Carboniferous
13. Select all of the following map projections that are equal area projections.
    a. Gall-Peters
    b. Mercator
    c. Mollweide

    d. Albers
14. Where on an HR diagram would you find a white dwarf?
    a. Bottom left
    b. Bottom right
    c. Top left
    d. Top right
15. What does a protostar become if it cannot gain enough mass?
    a. Main sequence star
    b. Red giant
    c. Blue straggler
    d. Brown dwarf
16. Which of the following astronomical techniques for measuring distance has the shortest range?
    a. Supernovae
    b. Redshift
    c. Cepheids
    d. Parallax
17. In what region of the EM spectrum does the Chandra telescope make observations?
    a. Infrared
    b. X-ray
    c. Radio
    d. Visible
18. Which of the following principles is used to derive the vis-viva equation?
    a. Conservation of angular momentum
    b. Conservation of energy
    c. Conservation of mass
    d. Conservation of orbital velocity
19. What two quantities are related with the Tully-Fisher relation?
    a. Rotation rate
    b. Mass
    c. Distance
    d. Luminosity
20. For a non-spinning massive object, which of the following expressions gives the radius of the innermost stable circular orbit?
    a. 6 GM / c^2
    b. 3 GM / c^2
    c. 2 GM / c^2

d. 6 GM / c^2

21. What type of fold does the image indicate?

a. Monocline
b. Syncline
c. Anticline
d. Oblique slip

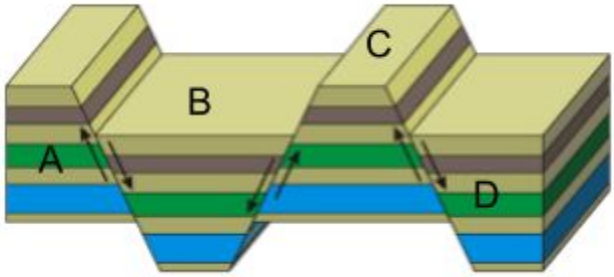
22. What is special about the Collignon map projection?
    a. It is a square
    b. It preserves the area that a land mass takes up in the real world
    c. It is the most common map projection
    d. Does not perfectly preserve land area nor form or distances, but is relatively close to all of them
23. What fossils are commonly found in marine depositional environments?
    a. Sponge
    b. Plankton
    c. Terrestrial plants
    d. No fossils
24. Who was the first person to circumnavigate the world alone?
    a. Prince Henry
    b. Ferdinand Magellan
    c. Amerigo Vespucci
    d. Joshua Slocum
25. Which is described by the definition: younger layers of rock cut across older layers of rock?
    a. Law of Superposition
    b. Law of Original Horizontality

c. Principle of Uniformitarianism
d. Cross Cutting Relationships

26. List the discontinuities in terms of depth, from least to most deep.
    a. Repetti discontinuity
    b. Lehman discontinuity
    c. Gutenberg discontinuity
    d. Mohorovicic discontinuity

a. ABDC
b. DACB
c. CDAB
d. CDBA

27. Which best describes the relative physical properties of the asthenosphere?
    a. Plastic, ductile, not brittle, and very weak rock
    b. Compressed strong rock
    c. Liquid metal
    d. Solid metal
28. What type of stress is put on a normal fault?
    a. Tension
    b. Shear
    c. Compression
    d. strain
29. What plate boundary do earthquakes typically occur at?
    a. Convergent
    b. Divergent
    c. Transform
    d. Hotspots
30. Below the thermocline, what happens to the temperature of the water?
    a. increases with increasing rate
    b. decreases with decreasing rate
    c. decreases with increasing rate
    d. increases with decreasing rate
31. Identify the graben in the horst-graben system.



a. A
b. B
c. C
d. D

32. According to Bowen's Reaction Series, what mineral is the last to crystallize?
    a. Muscovite
    b. Olivine
    c. Pyroxene
    d. Quartz
33. How do sills differ from dikes?
    a. Sills cut across existing rock beds, while dikes don't cut across older rock beds
    b. Sills don't cut across existing rock beds, while dikes do cut across older rock beds
    c. Sills are formed across vertical cracks while dikes are formed across horizontal cracks
    d. Dikes are concordant intrusive sheets, while sills are discordant intrusive sheets
34. Which of the following is the imaginary line on earth in which the magnetic declination is zero?
    a. Isogonic line
    b. Agonic line
    c. Isoclinic line
    d. Aclinic line
35. On which research vessel did Robert Ballard and his team discover the first active hydrothermal vent?
    a. Henry B Bigelow
    b. Alvin
    c. Knorr
    d. Nautilus