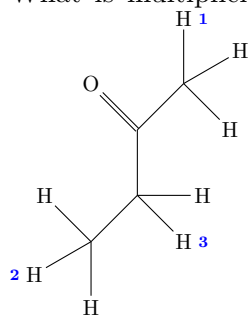


Section 1: CHEMISTRY

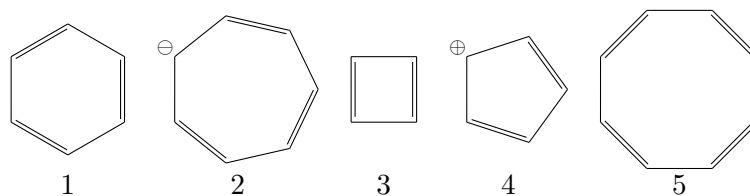
1. What amount of ortho-phosphoric acid (molecular weight 98 g/mol, H_3PO_4) in grams is needed to prepare 0.1N solution (100 ml)?
 - A. 0.327
 - B. 3.27
 - C. 32.7
 - D. 98
 - E. 0.98
2. Nucleic acids adsorb at 260 nm. Please choose the name for this wave region.
 - A. visible
 - B. UV
 - C. microwave
 - D. X-ray
 - E. radio
3. What is the electrode potential of magnesium in 0.01 M magnesium sulfate solution if the standard electrode potential E° of Mg/Mg^{2+} redox pair is -2,363 V?
 - A. -2,304 V
 - B. -2,422 V
 - C. -2,481 V
 - D. -2,540 V
 - E. None of these
4. ^{32}P -labeled ATP (400 μCu) was delivered to the lab on November 1, 2016. A radioactive isotope ^{32}P has 2 week half-life. How much activity still remains at January 1, 2017?
 - A. 400
 - B. 100
 - C. 50
 - D. 25
 - E. 0
5. Solubility of calcium carbonate in water is 1.5 mg/l at room temperature. What is the constant of solubility for this compound with molecular weight 100?
 - A. 1.5×10^5
 - B. 0.75×10^{-5}
 - C. 2.25×10^{-5}
 - D. 2.25×10^{-10}
 - E. 1.5×10^{-5}

6. What is multiplicity of the signals for the protons 1, 2, and 3 in $^1\text{H-NMR}$ spectrum of



- A. 1 - singlet, 2 - doublet, 3 - triplet
 B. 1 - singlet, 2 - triplet, 3 - doublet
 C. 1 - doublet, 2 - quadruplet, 3 - triplet
 D. 1 - singlet, 2 - triplet, 3 - quadruplet
 E. 1 - triplet, 2 - doublet, 3 - triplet

7. Which of the following are anti-aromatic structures?



- A. 1 and 2
 B. 3 and 4
 C. 2 and 5
 D. 2 and 4
 E. 3 and 5

8. Which of the following are p-type semiconductors?

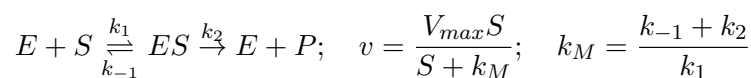
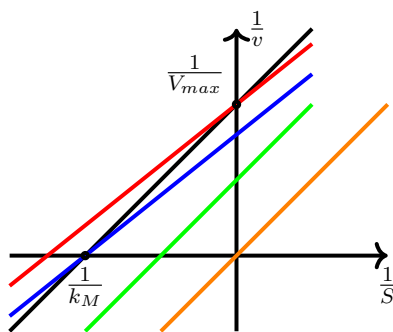
1. silicon doped with boron
2. silicon doped with phosphorus
3. germanium doped with aluminum
4. silicon doped with germanium
5. aluminum doped with indium

- A. 1, 2
 B. 1, 3
 C. 4, 5
 D. 3, 5
 E. 2, 5

9. To 100 ml of hydrogen peroxide solution in water, the excess of potassium iodide and sulfuric acid were added in the presence of molybdate catalyst. What was the initial concentration of hydrogen peroxide (in grams/l) if 800 ml of 0.01 M sodium thiosulfate solution in water was needed to reduce all iodine formed during the first step.

- A. 2.72
- B. 1.36
- C. 5.44
- D. 27.2
- E. 3.4

10. Choose which line corresponds to competitive inhibition of enzyme-catalyzed reaction (initial dependence is shown in black)



Here E is the enzyme, S is the substrate, V_{max} is the maximal reaction rate, and k_M is the Michaelis constant.

- A. red
- B. green
- C. blue
- D. black
- E. orange

Section 2: MATHEMATICS

11. The set of solutions to the following inequality is

$$\sqrt{x^2 - 3} > x - 1$$

- A. $x \leq -\sqrt{3}$ or $x \geq \sqrt{3}$
- B. $x \leq -\sqrt{3}$ or $x > 2$
- C. $x > 2$
- D. $0 \leq x < 2$
- E. None of these

12. If $f(x) = \sqrt{\sin 4x}$ then $f'(x) =$

- A. $\sqrt{\cos 4x}$

- B. $4\sqrt{\cos 4x}$
 C. $\frac{\cos 4x}{2\sqrt{\sin 4x}}$
 D. $\frac{2\cos 4x}{\sqrt{\sin 4x}}$
 E. None of these
13. $\lim_{x \rightarrow 0} \frac{\sqrt{1+2x} - \sqrt{1-2x}}{x} =$
 A. 0
 B. 1
 C. 2
 D. ∞
 E. None of these
14. The probability that a certain machine will produce a defective item is 0.30. If a random sample of 6 items is taken from the output of this machine, what is the probability that there will be more than 2 defectives in the sample?
 A. 0.1176
 B. 0.2557
 C. 0.4202
 D. 0.7443
 E. None of these
15. Joe suspects that a die is unfair and tosses it sixty times to record the count of each score from 1 to 6. He gets the following counts 11, 15, 8, 6, 7, and 13. What is the value of the relevant test statistic?
 A. 1.1
 B. 2.5
 C. 6.4
 D. 10.7
 E. None of these
16. The distance between the end of the vector $x = (2, 3, 1)$ and the plane spanned by the vectors $e_1 = (1, 2, 2)$ and $e_2 = (1, 3, 3)$ is
 A. $\frac{1}{2}$
 B. 1
 C. $\sqrt{2}$
 D. $\sqrt{6}$
 E. 2
17. Which of the following numbers is NOT an eigenvalue of

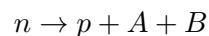
$$\begin{pmatrix} 1 & 4 & -2 \\ -2 & -5 & 2 \\ 3 & 3 & -2 \end{pmatrix}$$

- A. -1

- B. -2
 C. -3
 D. -4
 E. None of the above options
18. $\int_0^{\pi/6} \frac{1}{\cos x} dx =$
 A. $\frac{2}{\sqrt{3}}$
 B. $\frac{\sqrt{3}}{2}$
 C. $\ln 3$
 D. $\ln \sqrt{3}$
 E. The integral is divergent
19. Which of the following is the general solution to the differential difference equation $x_n = 6x_{n-1} - 9x_{n-2}$?
 A. $x_n = A \cdot 3^n$
 B. $x_n = (A + Bn) \cdot 3^n$
 C. $x_n = A \cdot n^3 - 3n^2 + B \cdot n$
 D. $x_n = A \cdot 3^n + B \cdot 3^{-n}$
 E. None of the above options
20. The minimum value of the function $f(x, y) = (x - 2)^2 + 2(y - 1)^2$ subject to the constraint $x + 4y \leq 3$ and $x \geq y$ is achieved at
 A. $x = \frac{5}{3}, y = \frac{1}{3}$
 B. $x = \frac{4}{3}, y = \frac{2}{3}$
 C. $x = 2, y = 1$
 D. $x = 1, y = \frac{2}{3}$
 E. None of the above options

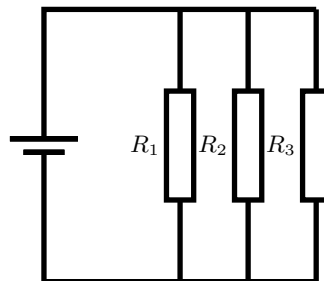
Section 3: PHYSICS

21. Define the missing particles (A and B) in the following decay

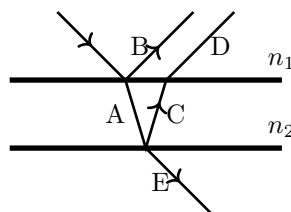


- A. e^+ and electron neutrino
 B. e^- and electron antineutrino
 C. e^+ and none
 D. e^- and electron neutrino
 E. e^- and none
22. Determine the electron configuration of a potassium atom in its ground state

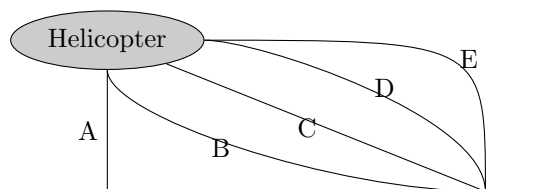
- A. $1s^22s^22p^63s^23p^64s^1$
 B. $1s^22s^22p^63s^23p^24s^1$
 C. $1s^22s^22p^63s^23p^64s^2$
 D. $1s^22s^22p^63s^23p^24s^2$
 E. None of the above
23. Water boils at 55°X and freezes at -55°X on a linear temperature scale X. What is a temperature of 300 K on the X scale?
 A. 0°X
 B. -50°X
 C. -28°X
 D. -25°X
 E. -44°X
24. If the object is placed in a focal plane of the convex lens with a focal length F , where the resulted image will be formed? Specify also whether it is inverted or not.
 A. at the back focal plane, inverted
 B. at the back focal plane
 C. at a distance of $2F$ from the lens, inverted
 D. at a distance of $2F$ from the lens
 E. at infinity
25. $U = 2\text{ V}$, $R_1 = 2\ \Omega$, $R_2 = 2\ \Omega$, $R_3 = 1\ \Omega$. The current in the circuit on the picture below is



- A. 4 A
 B. 2.5 A
 C. 0.4 A
 D. 1 A
 E. 1.6 A
26. Determine a phase shift relatively to the incident wave in each wave on the picture below. The refractive index $n_2 > n_1$.



- A. A 0, B 0, C 0, D 0, E 0
 B. A π , B 0, C π , D 0, E 0
 C. A 0, B π , C 0, D 0, E 0
 D. A 0, B π , C π , D 0, 0
 E. A π , B π , C 2π , D 3π , E 2π
27. An electric teapot contains 2 L of water. A power input of the kettle is 1.2 kW; its efficiency is 90%. Calculate the time needed to boil the water with an initial temperature of 10°C . The volumetric heat capacity of water is $4.2 \frac{\text{kJ}}{^\circ\text{C}\cdot\text{L}}$.
- A. 12 min
 B. 24 min
 C. 2 min
 D. 20 min
 E. None of the above
28. A 1 kg box rests on a table. Determine the weight W of the box and normal force F_n if a force of 10 N is pushing down on the box.
- A. $W = 10 \text{ N}, F_n = 10 \text{ N}$
 B. $W = 10 \text{ N}, F_n = 20 \text{ N}$
 C. $W = 10 \text{ kg}, F_n = 10 \text{ N}$
 D. $W = 10 \text{ kg}, F_n = 20 \text{ N}$
 E. $W = 10 \text{ N}, F_n = 0 \text{ N}$
29. An athlete on a road bike is moving downhill with a constant speed of 15 m/s. He brakes his bike to a stop with a constant acceleration of 5 m/s^2 . Calculate the total stopping distance of a bicycle.
- A. 22.5 m
 B. 12.5 m
 C. 22 m
 D. 45 m
 E. None of the above
30. A helicopter in the figure below is flying at a constant horizontal speed from left to right. A cargo box with supplies fell down from the helicopter. Which path better describes how the falling box as seen by a standing observer on the ground?



- A. A
 B. B
 C. C
 D. D
 E. E

Section 4: MOLECULAR BIOLOGY

31. Which of the following is not an RNA base?
- A. Adenine
 - B. Uracil
 - C. **Thymine**
 - D. Cytosine
 - E. Guanine
32. How many hydrogen bonds are formed between one A:T base pair?
- A. 1
 - B. **2**
 - C. 3
 - D. 4
 - E. 5
33. The sequence of amino acids in the polypeptide chain of a protein is called its
- A. **Primary structure**
 - B. Secondary structure
 - C. Tertiary structure
 - D. Quaternary structure
 - E. Holliday junction
34. Which of the following is an aromatic amino acid?
- A. Serine
 - B. Glutamine
 - C. Proline
 - D. Methionine
 - E. **Tryptophan**
35. Which of the following methods can separate particles on the basis of their density?
- A. FISH
 - B. **Centrifugation**
 - C. Ion exchange chromatography
 - D. SDS polyacrylamide gel electrophoresis
 - E. Affinity chromatography
36. The enzyme responsible for the initiation of DNA replication in prokaryotes is:
- A. DNA polymerase III
 - B. Taq polymerase
 - C. DNA polymerase I
 - D. **Primase**
 - E. DNA ligase

37. Which molecule does NOT participate in the elongation step of protein biosynthesis?
- EF-Tu
 - GTP
 - fMet
 - 18S ribosomal RNA
 - Aminoacylated tRNA
38. Which of the following is NOT a characteristic of eukaryotic transcription?
- TATA-binding protein
 - Regulation of initiation by transcription factors
 - Different types of RNA polymerases
 - Consensus promoter sequences at -10 and -35 positions
 - Transcription termination
39. Which of the following compounds is often utilized as a secondary messenger in cell signaling?
- GTP
 - Serotonin
 - Ca²⁺ ion
 - protein kinase A
 - AMP
40. Question REVOKED

Section 5: GENERAL BIOLOGY

41. The light-dependent phase of photosynthesis can be summarized by which of the following equations?
- $2\text{NADP}^+ + 2\text{H}_2\text{O} + 3\text{ATP} + \text{light} \rightarrow 2\text{NADPH} + 2\text{H}^+ + 3\text{ADP} + 3\text{P}_i + \text{O}_2$
 - $2\text{NADPH} + 2\text{H}_2\text{O} + 3\text{ADP} + 3\text{P}_i + \text{light} \rightarrow 2\text{NADP}^+ + 2\text{H}^+ + 3\text{ATP} + \text{O}_2$
 - $2\text{NADPH} + 3\text{ADP} + 3\text{P}_i + \text{light} \rightarrow 3\text{ATP} + 2\text{H}_2\text{O} + 2\text{NADP}^+ + 2\text{H}^+ + \text{O}_2$
 - $2\text{NADPH} + 2\text{H}_2\text{O} + 3\text{ADP} + 3\text{P}_i + \text{light} \rightarrow 2\text{NADP}^+ + 2\text{H}^+ + 3\text{ATP} + \text{O}_2$
 - $2\text{NADP}^+ + 2\text{H}_2\text{O} + 3\text{ADP} + 3\text{P}_i + \text{light} \rightarrow 2\text{NADPH} + 2\text{H}^+ + 3\text{ATP} + \text{O}_2$
42. Double fertilization in the flowering plants refers to a process in which
- One of the two sperm cells which recently underwent meiosis in the pollen tube fertilizes the egg and another fuses with the antipodal cell in the embryo sac producing diploid zygote and diploid feeding endosperm
 - One of the two sperm cells which recently underwent mitosis in the pollen grain fertilizes the egg and another fuses with two central nuclei in the embryo sac producing diploid embryo and triploid endosperm
 - One of the two sperm cells which recently underwent meiosis in the pollen grain fertilizes the egg and another fuses with two central nuclei in the embryo sac producing diploid zygote and triploid endosperm

- D. Two sperm cells which recently underwent mitosis in the pollen grain fertilize the egg and two synergids producing diploid zygote and triploid endosperm
- E. Two sperm cells which recently underwent meiosis in the pollen grain fertilize the egg and and a synergid producing diploid embryo and diploid endosperm
43. Kidney excrete harmful metabolites, primarily urea, and maintains water-salt balance. Blood enters renal glomerulus through the afferent arteriole and leaves by the efferent arteriole. Useful components including sodium ions are reabsorbed during the primary urine passage through the nephron. Low plasma salt concentration and reduced blood flow to the kidneys stimulate secretion of kidney-specific proteases, renin or angiotensin converting enzyme (ACE). Which of the five options below most accurately matches the gaps in the following sentence?

“Secreted by the kidney, _____ converts angiotensinogen to angiotensin I which is further converted by _____ to angiotensin II. Angiotensin II vasoconstricts _____ arteriole stronger than the _____ arteriole, suppresses the secretion of aldosterone by adrenal gland and _____ sympathetic system. Blood pressure goes _____ and sodium reabsorption from primary urine increases.”

- A. ACE / renin / afferent / efferent / activates / up
- B. ACE / renin / efferent / afferent / activates / up
- C. **renin / ACE / efferent / afferent / activates / up**
- D. renin / ACE / afferent / efferent / suppresses / down
- E. renin / ACE / efferent / afferent / suppresses / down
44. A healthy volunteer was subjected to a blood test before and after breakfast. What are the expected results?
- A. before meal: glucose 4, insulin 70, cortisol 70; after meal glucose 6, insulin 40 cortisol 40
- B. before meal: glucose 4, insulin 40, cortisol 40; after meal glucose 6, insulin 70 cortisol 70
- C. **before meal: glucose 4, insulin 40, cortisol 70; after meal glucose 6, insulin 70 cortisol 40**
- D. before meal: glucose 4, insulin 70, cortisol 40; after meal glucose 6, insulin 40 cortisol 70
- E. before meal: glucose 4, insulin 40, cortisol 40; after meal glucose 6, insulin 70 cortisol 40
45. A drug was injected intravenously into the left arm. During the first passage through the circulation it will be first found in the parenchymal tissues
- A. of the kidney
- B. of the liver
- C. of the heart
- D. of the brain
- E. **of the lung**

46. Blood group ABO is determined in the agglutination test by the presence of specific antigens A and B in red blood cells, or by the absence of both (group 0). The inheritance of alleles A, B and 0 follows simple mendelian segregation. Assume that the frequencies of these alleles in the population are $P_A = 1/4$, $P_B = 1/4$, $P_0 = 1/2$. If one parent was determined as AB by the agglutination test and another was determined as A, what is the probability that such parents will have a child with blood group B?

- A. 0
- B. $\frac{1}{16}$
- C. $\frac{1}{8}$
- D. $\frac{1}{4}$
- E. $\frac{1}{2}$

47. After the action potential is initiated in the cell body of the neuron, it propagates along the axon and reaches the neuromuscular junction. Which of the five options below most accurately fills in the gaps in the following sentence?

“The _____ of Ca^{2+} ions _____ the nerve terminal causes fusion of synaptic vesicles with the _____ membrane. The mediator activates nicotinic acetylcholine receptor, _____ crosses sarcolemma changing the membrane potential from approximately _____ mV to _____ mV. After hyperpolarization, the membrane potential is quickly restored by reverse transport of _____ ions.”

- A. **influx/into/presynaptic/sodium/-90/+75/potassium**
- B. efflux/out of/presynaptic/sodium/-90/+75/potassium
- C. influx/into/postsynaptic/sodium/-90/+75/potassium
- D. influx/into/presynaptic/potassium/-90/+75/sodium
- E. efflux/out of/presynaptic/sodium/+90/-75/potassium

48. Which cell of the adult vertebrate organism is not a product of the ectoderm or mesoderm?

- A. keratinocyte
- B. neuron
- C. endothelial cell
- D. striated myocyte
- E. **hepatocyte**

49. Autoimmune diseases result from abnormal activation of B-cells with naturally occurring epitopes that are present in the patient (self-antigens). Which of the following diseases is NOT autoimmune?

- A. Type I diabetes mellitus
- B. Multiple sclerosis
- C. **Duchenne muscular dystrophy**
- D. Psoriasis
- E. Rheumatoid arthritis

50. Which process is essential for fixation of rare advantageous recessive alleles in the population?

- A. Hetersis
- B. Imprinting
- C. Aromorphosis
- D. **Inbreeding**
- E. Haploinsufficiency