

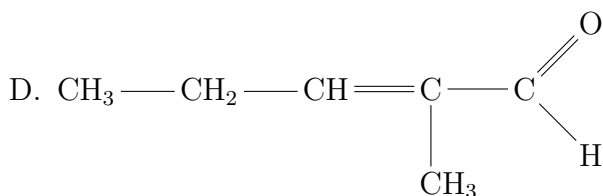
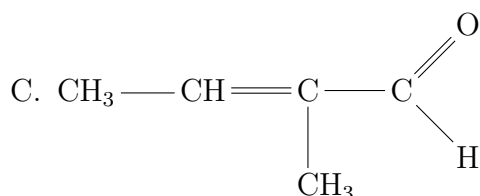
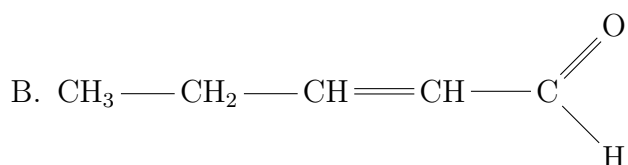
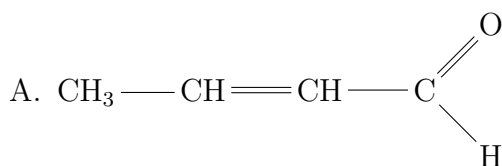
Section 1: CHEMISTRY

1. You have 10 g of the aluminum alloy with a metal. The mass portion of aluminum is 75%. The alloy was dissolved in the excess of diluted sulfuric acid. In the alloy with which metal the volume of released hydrogen will be maximal?
 - A. Li
 - B. Na
 - C. Mg
 - D. Fe
 - E. Cs
2. Diamond, graphen, fullerene, carbine are
 - A. Isomers
 - B. Allotropes
 - C. Nanoparticles
 - D. Metamaterials
 - E. Elements
3. What number of different insoluble solid compounds can be formed by pairwise mixing of 10% water solutions of (i) potassium bromide, (ii) silver nitrate, (iii) sodium carbonate, (iv) calcium chloride, (v) aluminum nitrate?
 - A. 2
 - B. 3
 - C. 4
 - D. 5
 - E. 6
4. Which of the following is a ferromagnetic metal?
 - A. Sodium
 - B. Copper
 - C. Nickel
 - D. Aluminum
 - E. Gold
5. Which compound the fastest reacts with bromine under light radiation?
 - A. Octane
 - B. Isooctane
 - C. Cyclohexane
 - D. Benzene
 - E. Methane

6. Which compound has a single signal in $^1\text{H-NMR}$ spectrum?

- A. Butane
- B. Isobutane
- C. Pentane
- D. **Neopentane**
- E. Isooctane

7. Which of the following compounds is a product of a base-catalyzed aldol condensation of propionaldehyde and acetaldehyde?



- E. **All of the above**

8. The equilibrium constant of the reaction $\text{H}_2 + \text{I}_2 = 2\text{HI}$ at a certain temperature is equal to 4 M^{-1} . What is the equilibrium concentration of HI if the initial concentrations of H_2 and I_2 were 0,08 M and 0.1 M, respectively?

- A. 0.020 M
- B. 0.044 M
- C. **0.088 M**
- D. 0.172 M
- E. None of the above

9. Which polymer is used for non-stick covering of pans?

- A. polyethylene
- B. polyethylene terephthalate
- C. **polytetrafluoroethylene**

- D. polyacrylonitrile
E. polyvinyl difluoride
10. What amount of sodium periodate (in moles) is needed for total oxidation of one mole of glucose?
- A. 1
B. 2
C. 3
D. 5
E. 7

Section 2: MATHEMATICS

11. If $f(x) = \sin^2 x^2$ then $f'(x) = ?$
- A. $\cos^2 x^2$
B. $2 \sin x^2 \cos^2 x$
C. $2 \sin x^2 \cos x^2$
D. $4x \sin x^2 \cos x^2$
E. None of these
12. $\int_0^{\frac{1}{2}} \frac{1}{x^2-3x+2} dx =$
- A. $\ln \frac{3}{2}$
B. $\ln 3$
C. 3
D. $\frac{1}{2}$
E. The integral is divergent
13. $\lim_{x \rightarrow 0} x^x =$
- A. 0
B. 1
C. e
D. $\ln 2$
E. The limit does not exist
14. The minimum value of the function $f(x) = 2x^3 + 3x^2 - 12x + 1$ on the interval $x \in [-4, 2]$ is
- A. -31

- B. -6
- C. -2
- D. 1
- E. None of these

15. Let A be the inverse matrix for $\begin{pmatrix} 5 & 1 & 3 \\ 0 & -1 & 1 \\ -1 & -1 & 0 \end{pmatrix}$. Then $a_{23} =$

- A. -5
- B. -4
- C. 4
- D. 5
- E. None of these

16. The angle between the vector $x = (1, -2, 4)$ and the plane spanned by the vectors $e_1 = (-1, 1, -1)$ and $e_2 = (-1, -1, 1)$ is

- A. $\cos^{-1} \sqrt{\frac{19}{21}}$
- B. $\cos^{-1} \sqrt{\frac{17}{21}}$
- C. $\tan^{-1} \frac{17}{19}$
- D. $\tan^{-1} \frac{2}{19}$
- E. $\pi/2$

17. Let $x(t)$ be a particular solution to $\frac{dx}{dt} = 1 + x^2$ with the initial condition $x(0) = 1$. Then $x(\frac{\pi}{12}) = ?$

- A. 0
- B. $\sqrt{3}$
- C. $e^{\pi/12}$
- D. $e^{-\pi/12}$
- E. None of the above options

18. Joe has two dice, one of which is normal and the other is biased so that it shows '6' 30% of times. He takes randomly one die and flips it. If it turns up '6', what is the chance that it is biased?

- A. 0.1236
- B. 0.6429
- C. 0.3571
- D. 0.5000
- E. 0.7812

19. I want to know the average statistics grade in a class. I take grades of all students and compute sample mean (\bar{X}) and sample standard deviation (s). When does it make sense to construct a 95% confidence interval using these data by formula $\mu = \bar{X} \pm t_{0.025} \frac{s}{\sqrt{n}}$?
- A. When sample size n is sufficiently large
 - B. When standard deviation is not too large
 - C. When population standard deviation is unknown
 - D. When margin of error is sufficiently small
 - E. **Never, because it is a census**
20. The maximum value of the function $f(x, y) = 5xy - 4$ subject to the constraint $\frac{x^2}{8} + \frac{y^2}{2} = 1$ is
- A. 1
 - B. 2
 - C. 4
 - D. **6**
 - E. 18

Section 3: PHYSICS

21. An athlete on a road bike rides up a hill at a constant speed of 10 km/h and returns down the hill to the initial point at a constant speed of 60 km/h. Calculate the average speed (S) and velocity (V) for his round lap.
- A. 35 km/h and -25 km/h
 - B. 70 km/h and -35 km/h
 - C. **17 km/h and 0 km/h**
 - D. 35 km/h and 35 km/h
 - E. 35 km/h and -50 km/h
22. A heavy cube with a mass of 100 kg is lying at rest on a horizontal surface. Determine which of the following statements correctly describes the situation if a horizontal force of 200 N is applied to the cube. Note that the coefficient of static friction is 0.25 and that of kinetic friction is 0.22.
- A. The cube is at rest and is subject to a friction force of 250 N
 - B. **The cube is at rest and is subject to a friction force of 200 N**
 - C. The cube is moving and is subject to a friction force of 200 N
 - D. The cube is moving and is subject to a friction force of 250 N
 - E. The cube is moving and is subject to a friction force of 50 N
23. The equation $y = 2A \sin 2\pi(\frac{t}{T} - \frac{x}{\lambda})$ represents a wave whose

- A. amplitude is $4\pi A$
 B. period is $T/2\pi$
 C. wave speed is x/t
 D. wave speed is λ/T
 E. phase velocity is in the negative x-direction
24. How many ice cubes are needed to cool down 0.2 L of still water from room temperature of 21°C to 9°C . Assume that the heat capacity of water is $4200 \text{ J}/(\text{kg}^\circ\text{C})$, the heat fusion of water is $330 \text{ kJ}/\text{kg}$. Ice cubes have the mass of 14 g each and are stored at 0°C .
- A. 1
 B. 2
 C. 3
 D. 4
 E. 5
25. Electron with energy of $W = 1,6 \cdot 10^{-19} \text{ J}$ is entering the area where the electric field strength $E = 300 \text{ kV}/\text{m}$, perpendicular to the direction of the field. Determine direction and strength of a magnetic field B that has to be applied so the electron will continue its moving without any changes in trajectory. The mass of the electron is assumed to be $9.1 \cdot 10^{-31} \text{ kg}$.
- A. $B = 0.5 \text{ kT}$, $B \perp E, B \perp V$
 B. $B = 0.1 \text{ T}$, $B \perp E, B \perp V$
 C. $B = 0.1 \text{ T}$, $B \perp E, B \parallel V$
 D. $B = 0.5 \text{ T}$, $B \perp E, B \perp V$
 E. $B = 0.5 \text{ kT}$, $B \perp E, B \parallel V$
26. Resistors R_a and R_b , with $R_a > R_b$, are connected to the battery – first in parallel, then in series, and after that individually. Rank all those arrangements according to the amount of current through the battery, from lowest to highest.
- A. series, parallel, R_a, R_b
 B. series, R_a, R_b , parallel
 C. parallel, R_b, R_a , series
 D. parallel, series, R_a, R_b
 E. R_a, R_b , series, parallel
27. An object is placed at 26 cm in front of a concave mirror. Determine the mirror focal length if it creates an upright image 1.5 times larger than an object.
- A. 78 cm
 B. 15.5 cm
 C. 50 cm

- D. -15.5 cm
E. -50 cm
28. The distance between two coherent light sources with a wavelength of 555 nm is 1 mm. Screen is placed at a distance of 1 m from the sources of light. Calculate the distance between the zero-order maximum and the first green fringe on the screen.
- A. **0.55 mm**
B. 0 mm
C. 1.1 mm
D. 0.1 mm
E. ∞
29. ^{197}Au , ^{195}Au and ^{196}Au are three isotopes of the element gold. Which one of the following is a true statement about the nuclei of these isotopes?
- A. All have the same number of neutrons
B. All have the same number of nucleons
C. **All have the same number of protons**
D. All have the same mass
E. None of the above
30. Define the missing particles (A and B) in the following decay with a half-life of 11 s:
 $^{23}_{12}\text{Mg} \rightarrow ^{23}_{11}\text{Na} + \text{A} + \text{B}$
- A. **e^+ and electron neutrino**
B. e^- and electron antineutrino
C. e^+ and none
D. e^- and electron neutrino
E. e^- and none

Section 4: MOLECULAR BIOLOGY

31. DNA-dependent RNA polymerase is an enzyme which performs
- A. Replication
B. **Transcription**
C. Translation
D. Reverse transcription
E. Reverse replication
32. Splicing is the process of

- A. Removal of introns and ligation of exons
 - B. Removal of exons and ligation of introns
 - C. Addition of multiple adenosine bases at the end of a primary RNA transcript
 - D. Removal of mutated regions of a primary RNA transcript
 - E. Addition of 5'-cap at the end of a primary RNA transcript
33. Which level of protein organization relies solely on the hydrogen bonds formation?
- A. Primary structure
 - B. Secondary structure
 - C. Tertiary structure
 - D. Quaternary structure
 - E. Double helix
34. Which of the following amino acids is positively charged at pH=7?
- A. Lysine
 - B. Glycine
 - C. Leucine
 - D. Glutamine
 - E. Aspartate
35. Affinity chromatography is a method that separates biomolecules on the basis of
- A. their sizes
 - B. their affinity to the charged insoluble stationary phase
 - C. their solubility in aqueous solutions
 - D. the different mobility in a gel matrix
 - E. highly specific interaction between molecules
36. Which of the following statements is NOT true for prokaryotic genomes?
- A. Genomic DNA can be methylated
 - B. Genes can be organized in clusters under control of a single promoter
 - C. Prokaryotic genomes contain specific sites for replication initiation
 - D. Genomic DNA is packaged into nucleosomes
 - E. Prokaryotic genomes contain genes that do NOT encode proteins
37. The majority of the eukaryotic messenger RNA molecules do NOT contain
- A. Internal Ribosome Entry Sites (IRES elements)
 - B. 3-untranslated regions
 - C. PolyA tails at their 3-ends
 - D. Long intervening non-coding regions (introns)

- E. 7-methylguanosine cap
38. Which statement about transfer RNAs' function is correct?
- A. tRNAs transfer information from a ribosome to an mRNA molecule
 - B. tRNAs contain a short region complementary to 18S ribosomal RNA
 - C. tRNAs always carry a covalently attached amino acid
 - D. tRNAs transport mRNA molecules to the place of protein synthesis
 - E. tRNAs form hydrogen bonds with mRNA molecules.
39. Which signaling compounds do NOT require interaction with membrane-bound receptors in order to transfer signal into the nucleus?
- A. cAMP
 - B. Peptide neurotransmitters
 - C. Steroid hormones
 - D. Ca^{2+}
 - E. Growth factors
40. The genes of the lactose operon in *E. coli* are strongly expressed when
- A. there is a lack of glucose in culture medium and LacI protein is bound at the lac operator
 - B. high levels of cAMP in the cell block the activity of the LacI protein
 - C. β -galactosidase cleaves the LacI protein
 - D. CAP (catabolite activator protein) is recruited at CAP-binding site and lactose is present in the medium
 - E. galactose-bound CAP (catabolite activator protein) is associated with the lac operator

Section 5: GENERAL BIOLOGY

41. The light-dependent phase of photosynthesis requires
- A. Light, H_2O , and CO_2
 - B. Light, H_2O , P_i , and ADP
 - C. Light, H_2O , P_i , ADP, and NADP^+
 - D. Light, H_2O , P_i , ADP, NADP^+ , and CO_2
 - E. Light, H_2O , P_i , ADP, NADPH, and CO_2

42. In the garden peas, the dominant allele R corresponds to round peas, the recessive allele r corresponds to wrinkled peas, L is the dominant allele for a long style, and l is the recessive allele for a short style. Loci R and L are genetically linked, being very close to each other on the same chromosome with recombination rate close to 0. Maternal plant with rrl genotype was pollinated by the pollen from F1 hybrid between rrl and RRLL. The progeny expected from this cross is
- A. Round peas with long style
 - B. Wrinkled peas with long style
 - C. Round peas with long style and round peas with short style
 - D. Round peas with long style and wrinkled peas with short style
 - E. Wrinkled peas with long style, wrinkled peas with short style, round peas with long style, and round peas with short style
43. Low plasma salt concentration stimulates secretion of renin by the kidney which activates the production of angiotensin I. The latter is converted to angiotensin II, a potent vasoconstrictor which activates sodium reabsorption, however at the expense of loss of potassium. Which of the following is true for a patient with stenosis of renal artery of one kidney?
- A. Low blood pressure, low renin, excess extracellular fluid, high plasma K^+
 - B. High blood pressure, high renin, normal extracellular fluid, normal K^+
 - C. High blood pressure, high renin, high extracellular fluid, low K^+
 - D. High blood pressure, high renin, low extracellular fluid, low K^+
 - E. High blood pressure, high renin, low extracellular fluid, high K^+
44. A drug taken orally (*per os*) was absorbed into the blood through the capillaries of the small intestine. Where will it be found next?
- A. kidney
 - B. lung
 - C. liver
 - D. heart
 - E. brain
45. Obese high fat diet fed mice (Ob) were compared with normal (N) mice on standard diet using insulin clamp test, when insulin (I) and glucose (G) are infused intravenously until the concentration of insulin and glucose plateaued. A trace amount of radioactive 3H -labelled G was added to measure hepatic G release. When compared to N mice, in Ob mice the steady state is reached at
- A. Higher I, higher G, higher $^3HG/G$ ratio than N mice
 - B. Lower I, lower G, lower $^3HG/G$ ratio
 - C. Higher I, lower G, lower $^3HG/G$ ratio
 - D. Higher I, higher G, lower $^3HG/G$ ratio
 - E. Higher I, lower G, higher $^3HG/G$ ratio

46. Blood group ABO is determined in agglutination test by the presence of the specific surface antigens A, B, or by the absence of both (group O). Patient AO can not be transfused with the blood from
- A. OO
 - B. AA
 - C. AO
 - D. BO
 - E. None of the above
47. It is illegal (in some countries) to develop human embryo in vitro beyond day 14, because by this day
- A. Blastocyst capable of implantation is formed
 - B. Primitive streak was formed and the site of gastrulation was determined
 - C. Gastrulation occurred and germ layers were specified
 - D. Neurulation occurred (neural tube invaginated from the ectoderm)
 - E. Buds of main organs are formed including the brain
48. Organophosphate type insecticides can cause death of humans by
- A. provoking blood clot formation
 - B. over activation of adrenergic receptors
 - C. over activation of cholinergic receptors
 - D. heart arrest
 - E. internal bleeding
49. Which of the following conditions is NOT a Mendelian type genetic disorder
- A. Duchenne muscular dystrophy
 - B. Huntington's disease
 - C. Sickle cell anemia
 - D. Cystic fibrosis
 - E. Down syndrome
50. Which of the following are NOT pituitary hormones?
- A. Follicle stimulating hormone
 - B. Adrenocorticotrophic hormone
 - C. Somatotropin
 - D. Gonadotropin releasing hormone
 - E. Prolactin