

THE UNIVERSITY OF MANITOBA

December 15, 2006
Paper # 467/468
CHEM / MBIO 2770

6:00 pm - 8:00 pm
Elements of Biochemistry I

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Final Examination
Examiners: Dr. J. O'Neil and
Dr. A. Scoot

Instructions

- Please mark the Answer Sheet using *PENCIL ONLY*.
 - Enter your *NAME* and *STUDENT NUMBER* on the Answer Sheet.
 - The exam consists of multiple choice questions. Enter your answers on the Answer Sheet.
 - There is only 1 correct answer for each question.
 - Please read each question *CAREFULLY*.
-

1. An organized network of reactions that synthesize molecules and consume free energy is best described by the word:
 - A) metabolism
 - B) condensation
 - C) catabolism
 - D) cannibalism
 - E) anabolism
2. Which statement about the hydrophobic effect is **correct**?
 - A) It is a major driving force in the ionization of proteins.
 - B) An organized water cage forms around non-polar hydrocarbons.
 - C) It is explained primarily in terms of hydrocarbon enthalpy.
 - D) There is no hydrophobic effect in the formation of the DNA double helix.
 - E) It is the primary reason that glycolysis is a free energy-releasing metabolic pathway.
3. Identify the **incorrect** statement.
 - A) The Gibb's free energy is the amount of energy available to do work.
 - B) Entropy is the degree of order in a system.
 - C) Enthalpy is the heat content of a system.
 - D) An exergonic reaction releases free energy.
 - E) An endothermic reaction absorbs heat.
4. Red wine at pH 3.3 contains about ___ times as much H^+ as skim milk at pH 6.4.
 - A) 1259
 - B) 3.1
 - C) 31
 - D) 9.7
 - E) $10^{6.4}$

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5. The percentage of glycine molecules having an uncharged amino group at pH 10.0 is close to? (pK_a values for glycine are 2.35 and 9.78.)
A) 18% B) 50% C) 62% D) 38% E) 82%
6. Which collection of amino acids is hydrophobic?
A) Ala, Lys, Val
B) Pro, Tyr, Glu
C) Gly, Asp, Gln
D) Val, Ile, Ala
E) Trp, Tyr, Asn
7. For any amino acid with a non-polar R-group, at any pH above the pI of the amino acid, the predominant form in solution will:
A) have a net positive charge.
B) have no net charge.
C) have a net negative charge.
D) have both positive and negative charges in equal concentration.
E) be a Zwitterion.
8. Which of the peptides would absorb light at 280 nm?
A) Val-Pro-Leu-Gly-Asp
B) Ala-Lys-His
C) Ser-Gly
D) Tyr-Ala
E) Gly-Gln-Glu
9. Which functional group is **not** found in amino acids?
A) H-N amino
B) C=O carbonyl
C) H-S thiol
D) H-O alcohol
E) P-O phosphoryl

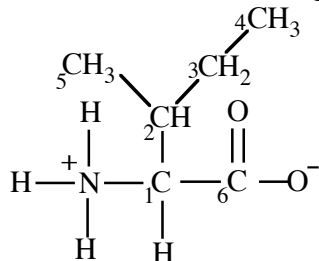
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10. Identify the chiral carbons in the following amino acid:



- A) 1 only
B) 3 and 5
C) 1 and 6
D) 1 and 2
E) 1, 3, and 4
11. The unique composition of collagen is accommodated in a structure called a:
- A) β -pleated sheet.
B) coiled coil.
C) triple helix.
D) helix-turn-helix motif.
E) double helix.
12. Which of the following statements about proteins is **false**?
- A) Most proteins are denatured by high temperature.
B) Carbohydrates are sometimes attached to proteins.
C) Non-polar amino acid side-chains are arranged on the inside of the protein where they avoid contact with water.
D) Most globular proteins are compact.
E) Most proteins are encoded by RNA genomes.
13. Identify the **correct** statement about size-exclusion chromatography of proteins:
- A) Big proteins enter the pores of the chromatography beads and elute slowly.
B) Proteins interact with the beads by binding SDS.
C) Small proteins are excluded from the chromatography beads and elute first.
D) Big proteins elute first because they are excluded from the pores of the beads.
E) Affinity of proteins for immobilized substrates on the beads provides the basis of separation.

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14. Proteolytic enzymes, phenylisothiocyanate, and careful control of pH are important in?
- A) Protein sequencing.
 - B) Amino acid analysis.
 - C) Preventing genetic mutations.
 - D) Protein purification.
 - E) Lipid analysis.
15. The quaternary structure of a protein means:
- A) The protein contains 4 subunits.
 - B) The association of 2 or more polypeptides forms a functional protein.
 - C) The protein is rich in turn structures.
 - D) The regular, repeating 3D structure of a protein.
 - E) The destruction or denaturation of the protein structure.
16. Identify the **correct** definition of hydrolase enzymes:
- A) They catalyze transfer of e^{-1} as H or H^{-} .
 - B) They catalyze group transfers.
 - C) They catalyze bond breakage through addition of water.
 - D) They catalyze addition to or formation of double bonds.
 - E) They catalyze group transfer yielding isomers.
17. For the following irreversible reaction, the relationship between activation energy and the rate constant of the reaction can be found by using which of the following equations?
- $$A \rightarrow P$$
- A) $K_m = \frac{k_{-1} + k_2}{k_1}$
 - B) $\Delta G^\circ = -RT \cdot \ln_e(K_{eq})$
 - C) $k = \frac{k_B \cdot T}{h} \cdot e^{(-\Delta G^\ddagger / R \cdot T)}$
 - D) $V = \frac{d[P]}{dt} = -\frac{d[S]}{dt}$
 - E) $V_0 = \frac{V_{max}[S]}{[S] + K_m}$

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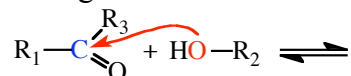
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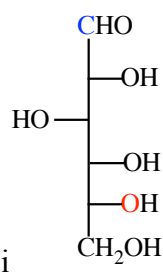
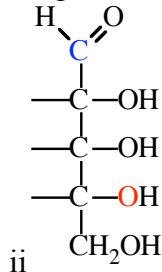
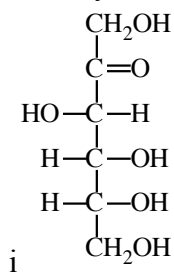
18. Identify the statement about allosteric enzymes that is **false**:
- A) They often consist of multiple subunits.
 - B) They exhibit Michaelis-Menton kinetics.
 - C) They exhibit cooperativity.
 - D) Their initial velocity shows a sigmoidal dependence on [S].
 - E) Their subunits often exist in different conformations.
19. An enzyme has a K_m for its substrate of 3×10^{-5} M. In one experiment, the initial velocity of the reaction catalyzed by the enzyme was measured at a substrate concentration of 2×10^{-3} M and was found to be 5×10^{-3} moles per litre per second. What would the rate of reaction have been if the substrate concentration had been 3×10^{-5} M?
- A) 2.5×10^{-3} moles per litre per second
 - B) 5×10^{-3} moles per litre per second
 - C) 1.5×10^{-5} moles per litre per second
 - D) 1×10^{-3} moles per litre per second
 - E) 10×10^{-5} moles per litre per second
20. Which of the following definitions **correctly** identifies the common name of the compound?
- A) Lactose = Gal ($\beta 1 \rightarrow 4$) Fru
 - B) Maltose = Glc ($\alpha 1 \rightarrow 4$) Glc
 - C) Iso-maltose = Glc ($\alpha 1 \rightarrow 4$) Glc
 - D) Sucrose = Fru ($\alpha 1 \rightarrow \beta 2$) Fru
 - E) Cellulose = (Glc $\alpha 1 \rightarrow 4$ Glc)_n
21. Which statement is **incorrect**?
- A) β -D-Glc can put all bulky substituents in the equatorial position so it is a very stable and abundant molecule.
 - B) Vitamin C is a sugar acid lactone.
 - C) Maltose, (O- α -D-glucopyranosyl-(1 \rightarrow 4) β -D-glucopyranose) is a non-reducing disaccharide.
 - D) Mutarotation is the interconversion of α - and β -glucose and can be measured by the rotation of polarized light.
 - E) Reduction of glyceraldehyde yields glycerol.

22. The product of the following reaction is:



- A) cyclic
- B) a hemiketal
- C) a thioester
- D) a hemiacetal
- E) trehalose

23. Identify the following compounds:



- | | | |
|--------------------|-----------------|-----------------|
| A) i = D-Galactose | ii = Lactose | iii = D-Ribose |
| B) i = D-Mannose | ii = D-Glycerol | iii = Vitamin C |
| C) i = D-Fructose | ii = D-Ribose | iii = D-Glucose |
| D) i = L-Fructose | ii = L-Mannitol | iii = D-Mannose |
| E) i = D-Fructose | ii = D-Glucose | iii = D-Ribose |

24. Which of the following statements about cellulose is **incorrect**?

- A) It's structure is $(\text{Glc } \beta 1 \rightarrow 4 \text{ Glc})_n$
- B) It consists of a linear polymer of 10,000 - 15,000 glucose units.
- C) Hydrolysis of cellulose yields the disaccharide cellobiose.
- D) It is a strong, rod-like structure of parallel chains packed side-by-side.
- E) It contains $\alpha 1 \rightarrow 6$ "Branch Points"

25. Which of the following statements about unsaturated bonds in fatty acids is **incorrect**:

- A) They lower fatty acid melting points.
- B) They are usually in the *cis* configuration.
- C) They kink the hydrocarbon chain.
- D) They are more common in fats than oils.
- E) They are commonly present in essential fatty acids.

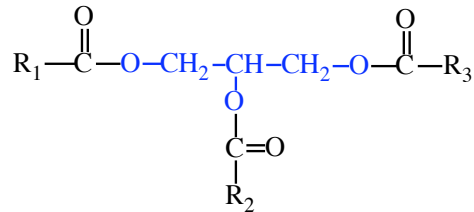
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26. Which statement about *trans*-fats is **incorrect**:
- A) They are found in high amounts in dairy products and meat.
 - B) Like saturated fatty acids they are a risk factor for coronary artery disease.
 - C) They raise levels of “bad” LDL cholesterol.
 - D) Their production by partial hydrogenation raises the melting points of fats.
 - E) When mixed with flour in baking products they produce a desirable texture.
27. Identify the following molecule:



- A) Cholesterol
 - B) Serine
 - C) Phosphatidic acid
 - D) Triacylglycerol
 - E) Testosterone
28. O, A, and B Blood Group Antigens are glycosphingolipids that:
- A) Differ in their ceramide group.
 - B) Differ in their fatty acid chain.
 - C) Differ in their sphingosine moiety.
 - D) Differ in their Serine group.
 - E) Differ in their complex carbohydrate head groups.
29. Identify the **incorrect** statement regarding the Sodium-Potassium ATPase:
- A) It is an integral membrane protein and active transporter.
 - B) It moves 2 K⁺ into the cell and 3 Na⁺ out of the cell.
 - C) It uses the energy of ATP to move ions against their concentration gradients.
 - D) It maintains cells' transmembrane electrical potential of 50-70 mVolts.
 - E) It is the direct cause of the cell becoming positively charged.
30. Identify the **correct** statement about cAMP and cGMP :
- A) They are a important carriers of free energy for anabolism.
 - B) They function as cellular “second messengers”.
 - C) They add flexibility to membranes.
 - D) They store the cell's genetic information.
 - E) They are pentoses.

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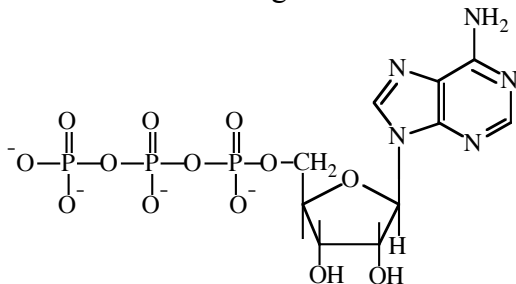
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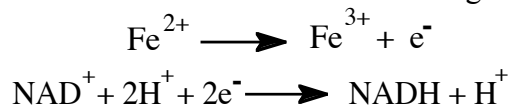
31. Double-stranded DNA was isolated from two different species. In species 1, cytosine was found to make up 15% of the bases and, in species 2, adenine made up 20% of the bases. Which of the statements is **true** about the melting temperatures (T_m) of the two DNA samples?
- A) The T_m values will be identical.
 - B) DNA from species 1 will have the higher T_m .
 - C) DNA from species 2 will have the higher T_m .
 - D) The question cannot be answered without knowing the percentages of all bases in each DNA.
 - E) T_m values cannot be predicted but must be measured experimentally.
32. The polymer (5') GCATTCGCAGG (3') could form a double-stranded structure with:
- A) (5') GGACGCTTACG (3')
 - B) (5') CGTAAGCGTCC (3')
 - C) (5') GGACGGCATTC (3')
 - D) (5') CCTGCGAATGC (3')
 - E) (5') GCATTCGCAGG (3')
33. Identify the **incorrect** statement about mutations:
- A) They are naturally occurring.
 - B) They involve changes in the sequence of DNA.
 - C) They cannot be repaired by cells.
 - D) They are important in aging and cancer.
 - E) They can involve covalent bonds between adjacent T bases.
34. Which statement about RNA is **incorrect**:
- A) RNA is the catalytic component of the lysosome.
 - B) Messenger RNA carries genetic information from the nucleus into the cytoplasm.
 - C) Ribosomal RNA is the most abundant class of RNA.
 - D) Messenger RNA forms a single-stranded, right-handed helix stabilized by base stacking.
 - E) MicroRNAs are about 22 base pair double stranded RNA molecules that regulate the expression of mRNA.

35. Which statement about the following molecule is **incorrect**?



- A) It contains a high-energy phosphoanhydride bond.
B) The 3' carbon of ribose is phosphorylated.
C) The 1' carbon of ribose is adenylated.
D) It is commonly referred to as the cell's "energy currency".
E) The nucleotide base is hydrophobic.

36. Identify the **correct** statement about the following reactions:



- A) Fe^{2+} is reduced to Fe^{3+} and NAD^{+} is oxidized to NADH.
B) The electrons in the first reaction are reduced and in the second reaction are oxidized.
C) NAD^{+} is reduced by 2 protons to NADH plus 1 free proton.
D) The reactions cannot form a redox couple.
E) NAD^{+} is reduced to NADH and Fe^{2+} is oxidized to Fe^{3+} .
37. Aconitase catalyzes the reaction Citrate \rightleftharpoons Isocitrate. The ΔG° for this reaction is +6.7 kJ/mole at 298 K. ($R = 8.3 \text{ J/mol} \cdot \text{degree}$). The equilibrium constant for this reaction is:
- A) 0
B) 0.997
C) 15
D) 0.67
E) 0.067

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38. The standard reduction potentials (E'^0) for the following half reactions are given.



Calculate the equilibrium constant for the reduction of Coenzyme Q by NADH as catalyzed by Complex I the electron transport chain. $R = 8.3 \text{ J/mol}\cdot\text{K}$, $T = 298 \text{ K}$, F (Faraday constant) = $96.4 \text{ kJ/volt}\cdot\text{mol}$ The value is ?

- A) 1.03
 - B) 7.3×10^{12}
 - C) 1.37×10^{-13}
 - D) 6.33×10^8
 - E) 1.58×10^{-9}
39. The conversion of one mole of glucose to two moles of glyceraldehydes-3-phosphate by the glycolytic pathway results in the net formation of:
- A) Four moles of ATP.
 - B) Two moles of NADH and two moles of ADP.
 - C) Two moles of ADP.
 - D) Two moles of NAD⁺ and two moles of ATP.
 - E) Two moles of ATP.
40. Reactions of glycolysis and the TCA cycle are regulated by compounds that signal the energy status of the cell: Identify the **correct** statement.
- A) Pyruvate dehydrogenase is activated by NADH.
 - B) α -ketoglutarate dehydrogenase is activated by Succinyl-CoA.
 - C) Phosphofructokinase is inhibited by ATP.
 - D) Pyruvate kinase is activated by acetyl-CoA.
 - E) Citrate synthase is inhibited by ADP.
41. Which of the following statements about mitochondria is **incorrect**?
- A) They contain their own DNA, tRNA, and ribosomes.
 - B) Their inner membrane contains all of the enzymes of the respiratory electron transport chain.
 - C) The mitochondrion is thought to be an ancient prokaryotic, aerobic bacterium that took up symbiotic residence in a primitive, eukaryotic, anaerobic host.
 - D) They contain an inner highly permeable membrane and an outer impermeable membrane.
 - E) The interior matrix contains pyruvate dehydrogenase, most of the TCA cycle enzymes, and enzymes involved in the oxidation of lipids and amino acids.

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42. Which of the following reactions is/are a substrate-level phosphorylation?
1) $\text{ATP} \rightarrow \text{ADP} + \text{Pi}$ 2) citrate \rightarrow isocitrate 3) malate \rightarrow oxaloacetate
4) succinylCoA \rightarrow succinate 5) phosphoenolpyruvate \rightarrow pyruvate
A) 4 & 5
B) 3 & 4
C) 2 & 5
D) 1
E) 1 & 3
43. Which of the following co-enzymes contains a nucleotide base also found in DNA and RNA?
1. Thiamine Pyrophosphate 2. Coenzyme A
3. Lipoate 4. FAD
5. NAD
A. 1, 2, 3, 4, and 5
B. 1 and 3
C. 3, 4 and 5
D. 2, 4, and 5
E. 1, 2, 4, and 5
44. Identify the **incorrect** statement regarding chemiosmotic coupling:
A) The intermembrane space of the mitochondrion becomes filled with protons during electron transport.
B) 10 protons are pumped for each 2 electrons transferred from NADH to oxygen.
C) 6 protons are pumped for each 2 electrons transferred from succinate to oxygen.
D) The passage of 10 protons through the ATP synthase releases enough free energy to make 1 ATP molecule from ADP and inorganic phosphate.
E) The free energy released in the oxidation of NADH is stored in an electrochemical proton gradient.
45. Choose the **best** explanation for why electron flow originating in FADH_2 results in the production of only 1.5 ATP molecules:
A) FADH_2 is a product of the TCA cycle.
B) When the electrons from FADH_2 are passed to UQ no energy is conserved in the pumping of protons by Complex II.
C) NADH cannot reduce FAD.
D) The electrons from FADH_2 are passed to UQ further down the electron transport chain.
E) FADH_2 passes only one electron to UQ resulting in UQ with a lower free energy.

LAB SECTION (Questions 46 to 60)

46. A 30 mL volume of 0.05 M arginine, initially at a pH of 1.2, was completely titrated with 0.1 M NaOH. What volume of the NaOH was required to do this? The pK_a values for arginine are 2.2, 9.0 and 12.5.
A) 5 mL B) 15 mL C) 30 mL D) 45 mL E) 60 mL
47. What is the pH of the solution in question 46 after the addition of 22.5 mL of the 0.1 M NaOH?
A) 5.6 B) 9.0 C) 10.7 D) 12.5 E) 13.5 or greater
48. What reaction is occurring when a solution of serine at its pI is titrated with NaOH?
A) $-\text{COOH} + \text{OH}^- \rightarrow -\text{COO}^- + \text{H}_2\text{O}$
B) $-\text{COOH} + -\text{NH}_2 \rightarrow -\text{COO}^- + -\text{NH}_3^+$
C) $-\text{COO}^- + -\text{NH}_3^+ \rightarrow -\text{COOH} + -\text{NH}_2$
D) $-\text{NH}_3^+ + \text{OH}^- \rightarrow \text{NH}_2 + \text{H}_2\text{O}$
E) $-\text{NH}^+ + \text{OH}^- \rightarrow -\text{NH} + \text{H}_2\text{O}$
49. In your experience in the biochemistry labs which of the following statements about paper chromatography are false?
1) Separation of sample components is based upon their partition between two immiscible liquid phases.
2) Water forms the stationary phase while a less polar solvent forms the moving phase.
3) The less polar a component the less it moves.
4) The more polar a component the more it moves.
5) The R_f is calculated by taking the ratio of the distance moved by a sample component over distance moved by solvent.
A) 1 and 2 B) 1, 2 and 5 C) 3 and 4 D) 2, 3 and 4 E) None are false.
50. Which of the following are required conditions for measuring protein by the Biuret method?
1) Alkaline conditions.
2) The presence of Cu²⁺.
3) Titration with acid and base.
4) Establishment of a calibration curve.
5) Formation of a complex whose absorbance can be determined.
A) 1, 2, 3, 4, 5 B) 1, 2, 3 and 4 C) 1, 2, 4 and 5 D) 4 and 5 E) 3

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51. Using the Biuret method, the absorbance of a tube containing 0.2 mL of a 1 in 5 dilution of unknown protein solution was found to be 0.300. In the same size cuvette, 1.5 mL of a standard bovine serum albumin solution containing 6 mg BSA/mL, gave an absorbance reading of 0.450. What is the protein concentration of the original protein solution?
- A) 1.2 mg/mL B) 6 mg/mL C) 30 mg/mL D) 100 mg/mL E) 150 mg/mL
52. Which of the following statements about a plot of V_0 vs. $[S]$ for an enzyme that follows Michaelis-Menten kinetics is *true*?
- A) As $[S]$ increases, the initial velocity of reaction V_0 decreases.
B) At very high $[S]$, the velocity curve becomes a horizontal line that intersects the y-axis at K_m .
C) K_m is the $[S]$ at which $V_0 = V_{max}$.
D) The shape of the curve is sigmoidal.
E) The y-axis is a rate term with units describing product formed/min.
53. An enzyme-catalyzed reaction was carried out with the substrate concentration initially a thousand times greater than the K_m for that substrate. After 9 minutes, 1% of the substrate had been converted to product, and the amount of product formed in the reaction mixture was 12 μmol . If, in a separate experiment, one-third as much enzyme and twice as much substrate had been combined, how long would it take for the same amount (12 μmol) of product to be formed?
- A) 1.5 min B) 13.5 min C) 27 min D) 3 min E) 6 min
54. The enzyme assay performed in the lab this term relied upon which of the following conditions?
- 1) Formation of a product whose absorbance could be determined.
2) Construction of a calibration curve.
3) Acidic conditions.
4) The presence of CuSO_4 to provide an oxidising agent.
5) Titration of the product with acid and base.
- A) 1 and 2 B) 1, 2 and 3 C) 1, 2 and 4
D) 1, 2, 3 and 4 E) 1, 2, 3, 4, 5

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55. If during an enzyme assay, the assay time was reduced from 10 min to 5 min how would this affect the values of K_m and V_{max} ?
- | | | | |
|----------|-----------|-----------|-----------|
| A) K_m | halved | V_{max} | halved |
| B) K_m | unchanged | V_{max} | halved |
| C) K_m | unchanged | V_{max} | unchanged |
| D) K_m | halved | V_{max} | unchanged |
| E) K_m | doubled | V_{max} | halved |
56. Which of the following statements about the T_m for DNA are true?
- 1) It is the temperature where half the DNA is single stranded and half is double stranded.
 - 2) It is the temperature at the midpoint of DNA denaturation.
 - 3) It is the midpoint of the transition temperature range for the DNA.
 - 4) It is the melting temperature of DNA.
 - 5) Its value is not related to the base composition of the DNA.
- A) 4 B) 2 and 3 C) 1, 2 and 3 D) 1, 2, 3 and 4 E) 1, 2, 3, 4 and 5

For questions 57 to 60 please refer to the following list of reagents:

1. Sodium dodecyl sulphate
2. Sodium carbonate
3. Ninhydrin
4. Orcinol
5. Hydrochloric acid
6. Copper sulphate
7. Aniline hydrogen phthalate
8. Resorcinol
9. Copper acetate
10. Isopentyl alcohol

57. Which of the following pairs will bring about furfural production and condense with the furural derivatives to form coloured complexes in Bial's test?
- A) 2 and 4 B) 6 and 4 C) 7 and 4 D) 5 and 8 E) 5 and 4
58. Which of the following pairs will act as staining reagents for paper chromatography?
- A) 1 and 3 B) 1 and 4 C) 3 and 4 D) 3 and 7 E) 7 and 10
59. Which of the reagents promotes ring opening in Benedict's test?
- A) 1 B) 2 C) 5 D) 8 E) 9

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60. Which of the reagents provides an oxidising agent in Barfoed's test?
A) 2 B) 5 C) 6 D) 7 E) 9