UNIVERSITY OF VICTORIA
FINAL EXAMINATION, DECEMBER 2013

CHEMISTRY 101 Fundamentals of Chemistry I

Time: ***3 hours***

Hand in only the bubble sheet at the end of the test period (3 hours).

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A02 CRN 10415 *Dr. S. McIndoe*
A03 CRN 10416 *Dr. S. Briggs*

Before you begin to write your exam you should find three items on your exam desk:

1) An exam placemat bearing your name. Sign this page. It will be collected during the exam when we check your student ID card. Do not use this page for scrap paper.
2) This exam question paper, containing an unstapled DATA sheet inside the cover page.
3) A bubble sheet (UVic Form A) for recording your answers. **PRINT and shade in only your LAST name, then first name, and the last 7 digits of your student ID number on the bubble sheet. *i.e.* Omit the leading V0.**

DO NOT CODE ANY COURSE, SECTION, OR DATE INFORMATION.

This exam question paper has 14 pages plus a DATA sheet. **Students must count the number of pages** in this examination paper before starting to write the exam. Report any discrepancy immediately to one of the instructors in the room.

This exam consists entirely of multiple choice questions. There are 65 multiple choice questions worth 2 marks each. TOTAL MARKS AVAILABLE = 130

This question paper contains enough blank space for working out the questions. No other paper is permitted.

The basic Sharp EL510 calculator and the Sharp EL-510 RNB are the only ones approved for use in Chemistry 101.

It is a University Calendar regulation that no student may arrive at the exam after the first half hour and no student may leave the exam in the first half hour.

If you finish your exam before 2¾ hours have elapsed then you may hand in your bubble sheet and leave. We ask that students not leave (*i.e.* that students remain seated) during the last 15 minutes of the exam so that everyone remaining may finish their exams without noise or disturbance.

DO NOT BEGIN UNTIL TOLD TO DO SO BY THE INVIGILATOR

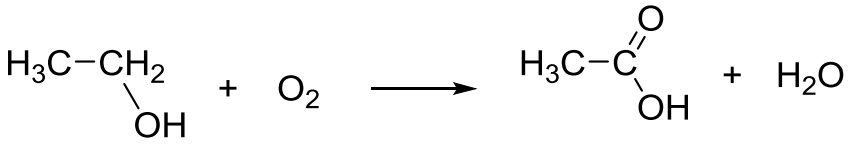
The answers must be coded on the optical sense form (bubble sheet) using a *SOFT PENCIL*.

***Select the* BEST *response for each question*.**

1. What is the lowest (shortest) wavelength photon that can promote the electron in a ground state hydrogen atom into an excited state?

A. 163 nm B. 122 nm C. 218 nm D. 247 nm E. 329 nm

2. What is the enthalpy change in kJ mol^{-1} during the following reaction (oxidation of ethanol to ethanoic acid)?



A. 413 B. -413 C. 24 D. -24 E. -108

3. A thermal neutron with a mass of 1.6749×10^{-27} kg and a velocity of 2200 m/s (with an uncertainty in velocity of 0.5%) has a minimum uncertainty in its position of:

A. 0.0143 nm B. 1.43 nm C. 2.86 nm D. 0.286 nm E. 1.14 nm

4. Why are the 3s, 3p and 3d orbitals degenerate (the same energy) in the hydrogen atom, but different in other atoms?

A. The hydrogen atom only has a single electron, and so the electron does not experience shielding of the nuclear charge from electrons in other orbitals.
B. The 3s, 3p and 3d orbitals all have the same number of nodes.
C. The 3s, 3p and 3d orbitals all have the same principal quantum number.
D. The ionization energy of the hydrogen atom is unusually low.
E. These orbitals are empty in the hydrogen atom, but filled for most other elements.

5. Why are metals good conductors?

A. They have low electronegativities.
B. Their electrons are localized in bonding orbitals.
C. They have a large band gap.
D. They have partially filled molecular orbital bands.
E. Their resistance drops to zero below a certain critical temperature.

6. An ultraviolet photon of frequency 3.08×10^{15} Hz striking a ground state hydrogen atom will promote an electron into an orbital with which principal quantum number?

A. 2 B. 3 C. 4 D. 5 E. ∞ (i.e. the atom is ionized)

7. Which of these ground state electron configurations is correct for the atom listed?

A. Rb = [Kr] $6s^1$
B. Lu = [Xe] $6s^2$ $5d^1$
C. Se = [Ar] $4s^2$ $3d^{10}$ $4p^3$
D. Al = [Ne] $3s^2$ $3d^1$
E. At = [Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^5$

8. Based on trends in the periodic table, which atom has the largest atomic radius?

A. K B. Cr C. Rb D. Kr E. Ga

9. The electronic configuration of the Cd^{2+} ion is

A. [Ar] $4d^{10}$ B. [Kr] $5s^2$ $4d^8$ C. [Kr] $5s^2$ $4d^{10}$ D. [Kr] $4d^{10}$ E. [Kr] $5s^1$ $4d^9$

10. Which of these anions has the smallest ionic radius?

A. O^{2-} B. Cl^- C. F^- D. S^{2-} E. N^{3-}

11. Which of these lattice energy relationships is correct? (The symbol > means 'is greater than'.)

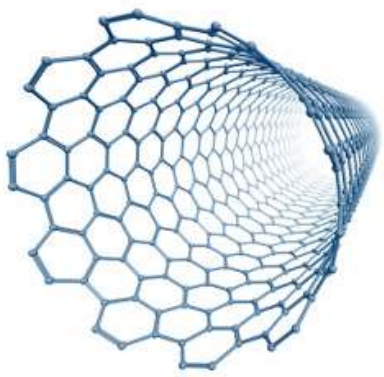
A. $In_2O_3 > Al_2O_3$
B. $NaCl > CaF_2$
C. KBr > NaF
D. SrS > ScN
E. MgO > SrSe

12. Which of the following techniques you learned about this year in the sections at the end of each chapter does NOT use light (*i.e.* electromagnetic radiation) to help determine molecular structure?

A. Vibrational spectroscopy
B. Visible spectroscopy
C. Mass spectrometry
D. X-ray crystallography
E. None of them

13. What is the hybridization state of carbon in a carbon nanotube (right)?

A. sp B. sp^2 C. sp^3 D. sp^3d E. sp^3d^2



14. What are the C-C-C bond angles in a carbon nanotube?

A. about 109.5° B. about 120° C. about 180°
D. about 60° E. about 90°

15. Which of these allotropes of carbon has an orbital hybridization different from that of all the others?

A. graphite B. single-walled carbon nanotubes C. graphene
D. diamond E. multi-walled carbon nanotubes

16. What is the molecular geometry of SF_3N? (S is the central atom)

A. See-saw
B. Trigonal bipyramidal
C. Square planar
D. Tetrahedral
E. Trigonal pyramidal

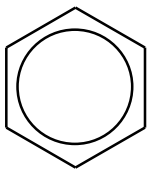
17. What is the molecular geometry of $[SnCl_5]^-$?

A. Tetrahedral
B. See-saw
C. Octahedral
D. Trigonal pyramidal
E. Trigonal bipyramidal

18. What is the molecular geometry of $[TeI_4]^{2-}$?

A. Tetrahedral
B. See-saw
C. Square planar
D. Trigonal bipyramidal
E. Octahedral

19. The abbreviated structure of benzene is shown. There are three ways to replace two hydrogen atoms with two fluorine atoms to give difluorobenzene. Which ones are polar?



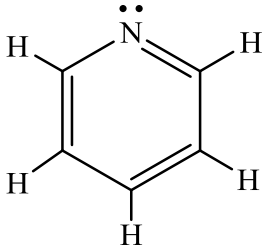
A. *ortho*-difluorobenzene
B. *meta*-difluorobenzene
C. *para*-difluorobenzene
D. *ortho*-difluorobenzene and *meta*-difluorobenzene
E. all of them

20. For which fluorobenzene is it impossible to draw a non-polar isomer?

A. $C_6H_4F_2$
B. $C_6H_3F_3$
C. $C_6H_2F_4$
D. C_6HF_5
E. C_6F_6

21. The molecule pyridine is shown to the right. In which type of orbital do the non-bonding electrons reside?

A. s B. p C. sp D. sp^2 E. sp^3



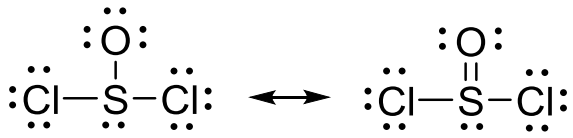
22. How many Lewis structures (resonance structures) that obey the octet rule can you draw for pyridine (structure shown above)?

A. 2 B. 3 C. 4 D. 5 E. 6

23. In the normal valence bond description of bonding, how many unhybridized p orbitals are there in a molecule of pyridine?

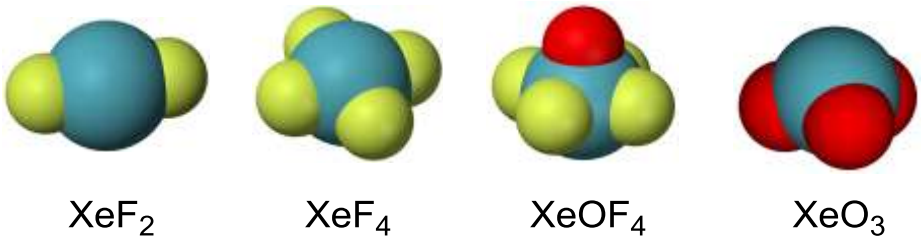
A. 2 B. 3 C. 4 D. 5 E. 6

24. Inspect the following resonance structures, and identify the INCORRECT statement about the $SOCl_2$ molecule.



A. The shape of the molecule is trigonal pyramidal
B. The S-O bond distance is longer than the S-Cl bond distance.
C. The Cl-S-O bond angle is greater than the Cl-S-Cl bond angle.
D. S has a partial positive charge.
E. The S atom is sp^3 hybridized.

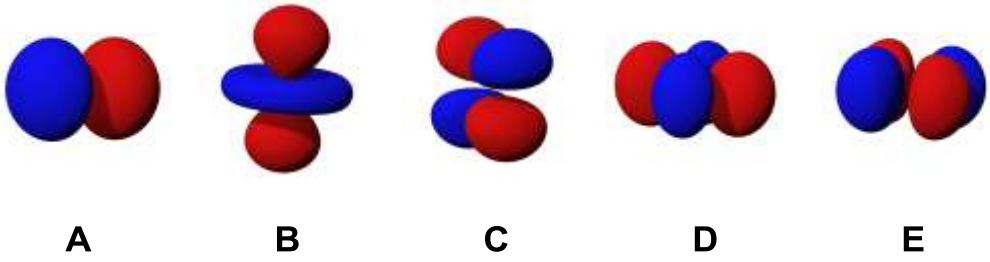
25. Which of the following compounds of xenon has more than one non-bonding pair of electrons on the xenon atom?



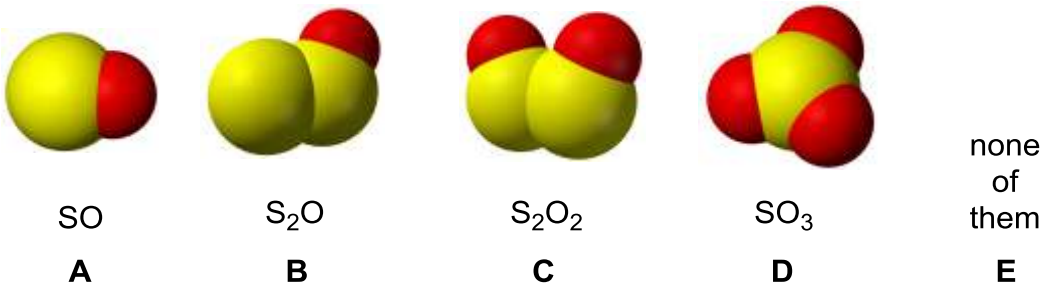
A. XeF_2 only B. XeF_4 only C. XeF_2 and XeF_4

D. XeF_2, XeF_4 and XeO_3 E. All of them

26. Which of the orbitals below is NOT a d orbital?



27. Which of the oxides of sulfur shown below is non-polar?



28. Which of the following orbitals has the most nodes?

A. 4s B. 4p C. 4d D. 4f E. 5s

29. Consider the following 5 white solids: sodium chloride (NaCl); glucose ($C_6H_{12}O_6$); quartz (SiO_2); polypropylene ($C_{3n}H_{8n}$); and dry ice (solid CO_2). Which has the lowest strength intermolecular forces?

A. Sodium chloride
B. Glucose
C. Dry ice
D. Polypropylene
E. Quartz

30. Of the substances named in this question, which are covalent network solids?

A. Polypropylene only
B. Quartz only
C. Dry ice only
D. Quartz, polypropylene and dry ice
E. Quartz and polypropylene

31. Of the substances named in this question, which are molecular solids?

A. Glucose only
B. Polypropylene only
C. Dry ice (solid carbon dioxide) only
D. Glucose, polypropylene and dry ice
E. Glucose and polypropylene

32. Which of the following elements has the highest melting point?

A. Rb B. Y C. Nb D. Ag E. Cd

33. Which of these molecules would be expected to have the lowest boiling point?

A. Pentane
B. 2-methylhexane
C. 2,3-dimethylpentane
D. 2-methylbutane
E. 2,2-dimethylpropane

34. Which of these substances is NOT a semiconductor?

A. Si B. InP C. GaAs D. Ge E. KCl

35. Why is AgCl INSOLUBLE in water?

A. Ion-dipole forces between water and Ag^+ and Cl^- ions are not strong enough to overcome the lattice energy.
B. AgCl forms a strong covalent bond that cannot be broken by ion-dipole forces.
C. AgCl has no dipole with which to interact with the polar water molecule.
D. There is no hydrogen bonding between water and AgCl.
E. AgCl is a semiconductor with a large band gap.

36. Doping small amounts of phosphorus (P) atoms into silicon (Si) creates what sort of substance?

A. insulator
B. *p*-type semiconductor
C. *n*-type semiconductor
D. metal
E. ionic lattice

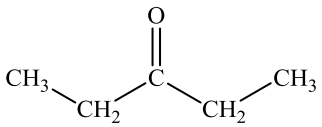
37. Which of the following properties do superconductors exhibit?

A. Expulsion of magnetic fields.
B. Zero resistance to electrical current.
C. A critical temperature above which superconducting properties break down.
D. A and B only.
E. All of A, B, and C.

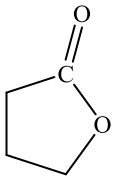
38. How many isomers of butene (linear C_4H_8) are there? (linear = unbranched)

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

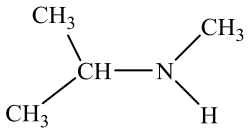
The next 6 questions concern the following collection of molecules, labelled P-Z.



P



Q



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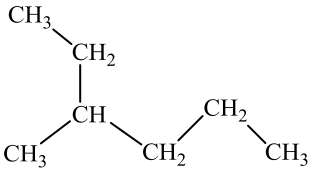
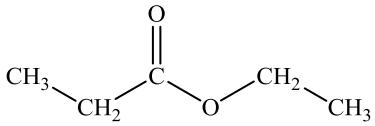
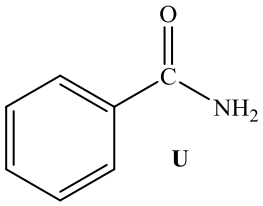


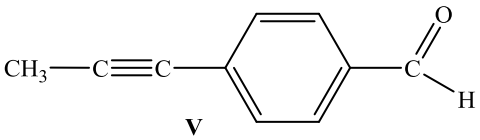
S



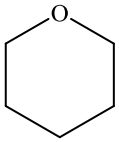
T



U



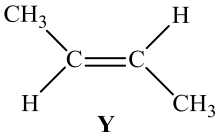
V



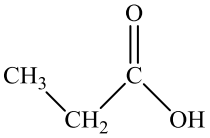
W

CH_3CH_2OH

X



Y



Z

39. Which compound is chiral?

A. Q B. V C. S D. T E. U

40. Which compound could be formed as a product of a reaction between two of the others?

A. P B. T C. V D. X E. Z

41. Which of these compounds is an ether?

A. P B. W C. X D. Q and T E. Q, T and W

42. Which of these compounds is an aldehyde?

A. P B. Q and T C. V D. Q, T, V and Z E. Z

43. How many of these compounds can form hydrogen bonds with other molecules of the same kind?

A. 2 B. 3 C. 4 D. 5 E. 6

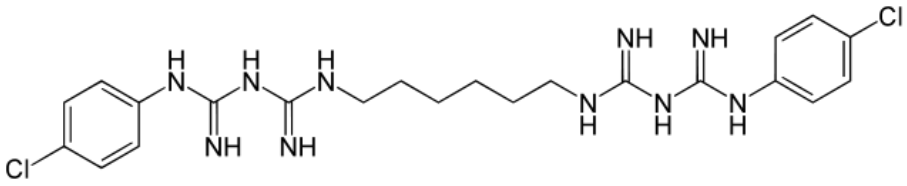
44. Assuming CH bonds are non-polar, how many of these molecules are non-polar?

A. 2 B. 3 C. 4 D. 5 E. 6

45. Which of these elements has the highest second ionization energy?

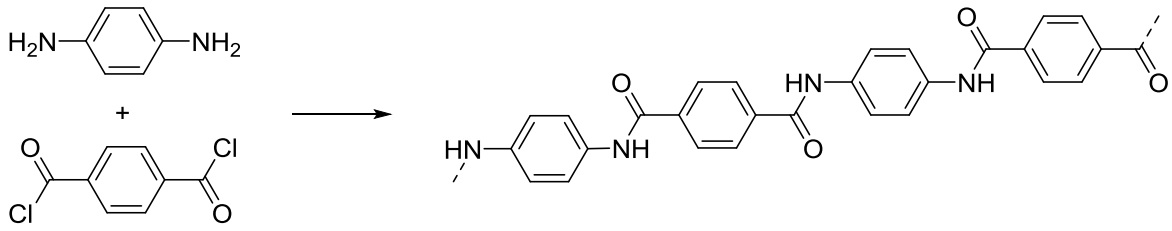
A. Li B. Be C. B D. O E. F

46. Chlorhexidine (shown below) is a water-soluble antiseptic that works by disrupting the cell membranes of bacteria, thus killing them. What force is principally responsible for it being very soluble in water?



A. Ionic bonding
B. Ion-dipole forces
C. Hydrogen bonding
D. Dipole-dipole forces
E. London dispersion forces

47. Aramid is a condensation polymer that may be prepared by the combination of the two molecules below. A small molecule is eliminated during the reaction. What is it?



A. H_2O B. HCl C. NH_2Cl D. NH_3 E. CO

48. Which of the following compounds is NOT an addition polymer?

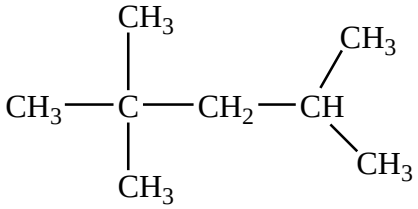
A. Polyethylene (PE)
B. Polypropylene (PP)
C. Polystyrene (PS)
D. Polyvinylchloride (PVC)
E. Polyethylene terephthalate (PET)

49. How many different isomers are there of hexane (C_6H_{14})?

A. 2 B. 3 C. 4 D. 5 E. 6

50. Isooctane (skeletal structure shown below) defines the 100 point on the octane rating scale of gasoline.

What is its correct systematic name?



A. 1,1,1,3-tetramethylbutane
B. 2,4,4-trimethylpentane
C. 2,2,4-trimethylpentane
D. 1,1,1,3,3-pentamethylpropane
E. 2,2,4-trimethyloctane

51. Ionic liquids always…

A. are soluble in water.
B. display ordered phases above their melting point.
C. have high lattice energies.
D. have melting points below 0°C.
E. consist of polyatomic ions.

52. Which of the following materials involves semiconductors?

A. Liquid crystal displays
B. Light-emitting diodes
C. Ionic liquids
D. Ceramics
E. High density polyethylene

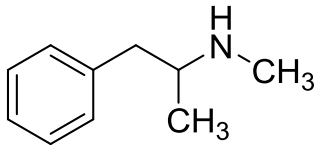
53. Enantiomers do NOT ever display different…

A. Smells
B. Tastes
C. Pharmaceutical effects
D. Reactivity with other chiral molecules
E. Melting points

54. Which of these molecules is chiral?

A. CH_4 B. CH_3Cl C. CH_2ClBr D. $CHClBrI$ E. CCl_2BrI

55. The freebase form of crystal meth is shown below. It is…



A. An achiral amine
B. A chiral amine
C. A chiral amide
D. An achiral amide
E. Incapable of hydrogen bonding

56. Reaction of an alcohol with a carboxylic acid produces

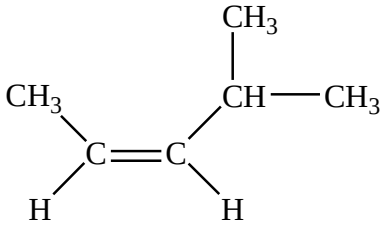
A. an ester
B. an amide
C. an ether
D. a ketone
E. an aldehyde

57. Reaction of an amine with a carboxylic acid produces

A. an ester
B. an amide
C. an ether
D. a ketone
E. nothing

58. Addition of H_2 to *cis*-4-methyl-2-pentene (structure shown) (with the help of a catalyst such as Ni) produces …

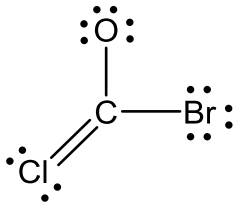
A. 4-methylpentane
B. hexane
C. *cis*-4-methylpentane
D. *trans*-4-methylpentane
E. 2-methylpentane



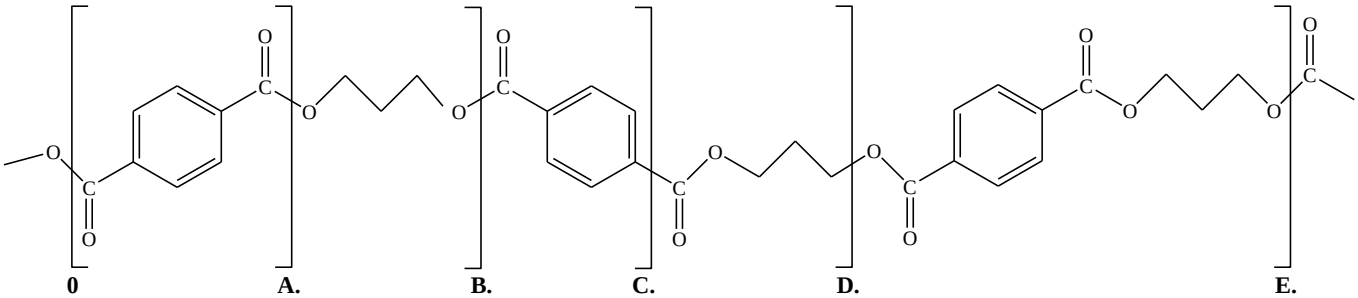
59. Consider the following resonance structure. The correct formal charges for the Cl and the Br are, respectively:

A. 0 and –1 B. +1 and 0 C. –1 and 0

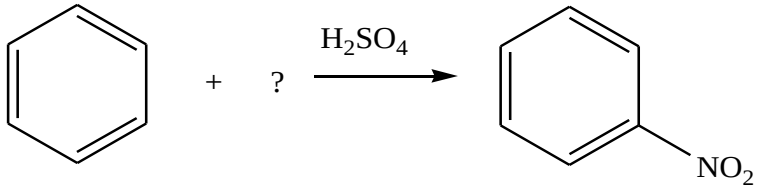
D. –1 and –1 E. 0 and 0



60. The structure of polytrimethylene terephthalate (PTT) is shown below. Starting at the point "0", which point includes exactly one repeating unit of this polymer?

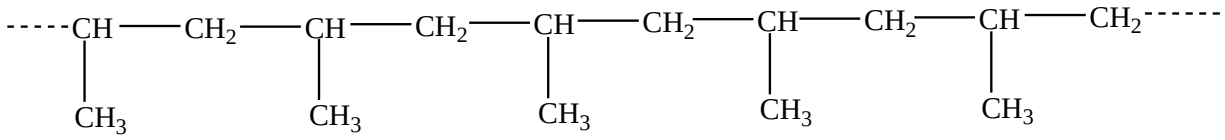


61. In the following reaction, the missing reactant (represented by a question mark) is ?

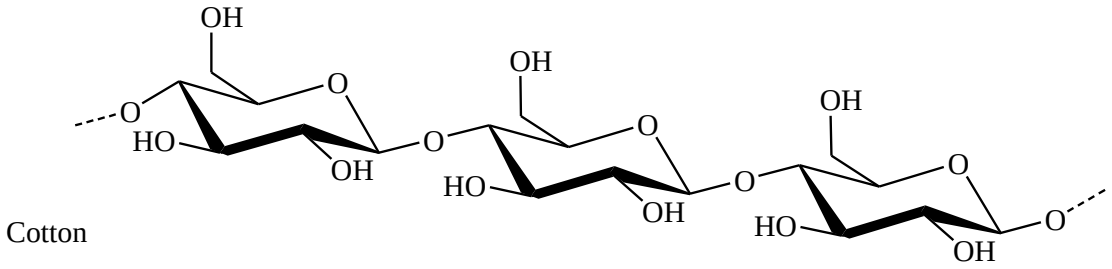


A. HCN B. NH_3 C. N_2O D. HNO_3 E. NO

62. Molecular structures for the two polymers polypropylene and cotton are shown below:



Polypropylene



Cotton

Polypropylene is widely preferred over cotton for the manufacture of athletic and outdoor clothing because…?

A. Polypropylene is cheaper than cotton.
B. Polypropylene is tougher than cotton.
C. Polypropylene is synthetic.
D. Polypropylene bonds with water less strongly than cotton bonds with water.
E. Polypropylene bonds with water more strongly than cotton bonds with water.

63. If part of a Liquid Crystal Display (LCD) (such as on a cell phone) is heated, that part of the screen will go black. Why?

A. The molecules become locked in position, and can no longer affect polarized light.
B. The liquid crystal phase becomes a normal liquid phase, which is unable to affect polarized light.
C. The nematic liquid crystal phase transforms into a smectic liquid crystal phase, which is unable to affect polarized light.
D. The liquid crystal molecules react with each other to form a polymer, which is unable to affect polarized light.
E. Light is efficiently absorbed by hot molecules.

64. A certain solid is very hard and has a very high melting point. Neither the solid nor the liquid formed when it is melted conducts electricity. What class of solid is this substance?

A. polymer B. ionic C. metallic
D. molecular E. covalent network

65. Which substance would be the most rigid?

A. Linear (unbranched) polyethylene

B. Linear polyethylene with plasticizer added

C. Branched polyethylene

D. Cross-linked polyethylene

E. Natural rubber

END