Printed ***Last*** Name: |___|___|___|___|___|___|___|___|___|___|___|___|

Printed ***First*** Name: |___|___|___|___|___|___|___|___|___|___|___|___|

Social Security # |___|___|___| |___|___| |___|___|___|

School: |___|Barnard |___|College |___|Engineering |___|General Studies

Chemistry 1403x Section 4 (Turro) Make Up Final Exam January 23, 2004

INSTRUCTIONS

Be certain you have an exam with 20 pages of questions. You should also have a periodic table, some selected equations and conversion factors attached and a BUBBLE SHEET

On the EXAM, fill in your name and CUID number (as indicated above).

On the BUBBLE SHEET:

1) On **Side 2 of the Bubble Sheet** print your first and last name in the box provided.

2) Then fill in your Social Security **IDENTIFICATION #** in the space provided.

3) Using a **soft lead pencil**, blacken the one response that best answers the question or completes the statement. There is only one correct answer to each question. Any question with more than one answer will not be counted.

4) Your score will be the **total number of correct answers**; therefore, it is to your advantage to answer every question.

5) **There are 75 QUESTIONS. They are equally weighted.**

UNDER NO CIRCUMSTANCES are you to make marks on the bubble sheet except in the appropriate *bubbles* for marking an answer you believe to be correct.
You may write on the exam sheets themselves for the purpose of doing calculations.

A **PERIODIC TABLE OF THE ELEMENTS** can be found at the end of this exam.

A **SCRATCH SHEET** is provided at the end of the exam**.**

You will be given three HOURS to complete the exam.

WHEN YOU HAVE FINISHED THE EXAM or at the end of the allowed time, deposit the **exam** and the **bubble sheet** in the **separate** boxes provided at the front of the room.

DO NOT FORGET! Print your first and last names in the box provided (1) on the bubble sheet, and (2) on the front page of the 10-page exam.

REMEMBER! It is your responsibility to ensure that your bubble sheet and exam sheets are properly identified.

1.Which electron excitation in a hydrogen atom requires the most energy?

a. $2p^1$ to $3s^1$
b. $2p^1$ to $4d^1$
c. $3p^1$ to $4s^1$
d. $5p^1$ to $6s^1$
e. $3p^1$ to $3d^1$

2. Which statement is true?

a. All atoms of the same element have the same mass.
b. The mass of an atom always equals the sum of the number of protons and electrons.
c. The mass of an atom can be expressed in units of grams only.
d. The mass of any atom is defined relative to the mass of an atom of carbon-12.
e. None of the above are true.

3. Which color of visible light has photons of lowest energy?

a. Blue
b. Green
c. Red
d. Violet
e. Yellow

4. Which electron configuration represents an excited state for a neutral atom?

a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
b. $1s^2 2s^2 2p^6 3s^1 3p^3$
c. $1s^2 2s^2 2p_x^{\ 1} 2p_y^{\ 1} 2p_z^{\ 1}$
d. All of these represent excited states.
e. None of these represent excited states

5. A monoatomic ion X^{2+} has 25 electrons and 29 neutrons.
What is the identity of element X?

a. Mn
b. V
c. Co
d. Cu
e. Ni

6. Consider the table below and then, from among the given choices (a-e), which pair of elements will form the most polar bond?

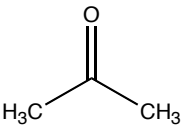
Element	Electronegativity
P	1.0
E	1.4
R	2.1
S	2.2
T	3.2

   a. P and E
   b. E and T
   c. S and T
   d. R and S
   e. P and R

7. The CCl_4 molecule is a
   a. polar molecule with polar bonds
   b. nonpolar molecule with nonpolar bonds
   c. polar molecule with nonpolar bonds.
   d. nonpolar molecule with polar bonds.
   e. None of the above are correct

8. According to valence bond theory, methane (CH_4), ammonia (NH_3), and water (H_2O) all involve sp^3 hybridization. Why do these molecules have different bond angles?
   a. The central atom has a different number of valence electrons.
   b. These molecules can form a different number of hydrogen bonds.
   c. These molecules have different electronegativities for the central atom.
   d. These molecules have different numbers of lone electron pairs
   e. These molecules have an octet of electrons.

9. An unknown element E reacts with excess oxygen to produce a compound with molecular formula E_2O_3. When 36.0 g of E is used, 50.4 g of the compound is produced. Determine the atomic mass of E.
   a. 30.0 $g.mol^{-1}$
   b. 36.0 $g.mol^{-1}$
   c. 60.0 $g.mol^{-1}$
   d. 120. $g.mol^{-1}$
   e. 16.0 $g.mol^{-1}$

10. Determine the number of C atoms in 697 g of acetone, 
    a. 3.00
    b. 36.0
    c. 7.23×10^{24}
    d. 2.17×10^{25}
    e. 6.03×10^{23}

11. What is the empirical formula of a compound used as fertilizer that contains 35.0% nitrogen, 5.0% hydrogen, and 60.0% oxygen by mass?
    a. $N_2H_4O_3$
    b. $N_2H_8O_3$
    c. $N_4H_8O_3$
    d. N_7HO_{12}
    e. None of the above are correct.

12. Which of these gaseous atoms requires the most energy to remove a single electron from a neutral atom?
    a. Cl
    b. Ar
    c. Br
    d. Kr
    e. F

13. Which principle correctly explains the relative sizes of the following species?
    Ar K^+ Cl^- Ca^{2+} S^{2-}
    a. The species are isoelectronic and thus must have the same size.
    b. Negative ions are larger than neutral atoms, which in turn are larger than positive ions.
    c. The heavier the species, the larger its size, because heavier species contain a larger number of electrons and these require more space.
    d. These species are isoelectronic, thus their sizes decrease as the number of protons increases due to an increased attraction for electrons.
    e. None of the above are related to the relative sizes of the species.

14. In which are the bonds ranked in order from smaller to greatest polarity (left to right)?
    a. N-N < N=N < N≡N
    b. N-P < N-N < N-O
    c. I-I < Br-Br < Cl-Cl
    d. Si-C < Si-N < Si-O
    e. C-H < OH < NH

15. What is the smallest whole-number coefficient for O_2 in the balanced equation for the reaction of C_3H_6 with NH_3 and O_2 to form C_3H_3N and H_2O?
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5

16. Which are the empirical (simplest) formulas?

I	II	III	IV
NaCl	Fe_2O_3	C_6H_6	CH_3COOH

    a. I only
    b. I and II only
    c. II and III only
    d. I, II, and IV only
    e. None of the above choices is correct.

17. How many moles of O_2 combine with 0.325 mol of S_8 to form SO_3?
    a. 0.217 mol
    b. 0.325 mol
    c. 0.488 mol
    d. 3.90 mol
    e. 3.25 mol

18. Which is a third-period element with chemical properties most like those of carbon?
    a. B
    b. Ge
    c. S
    d. Si
    e. P

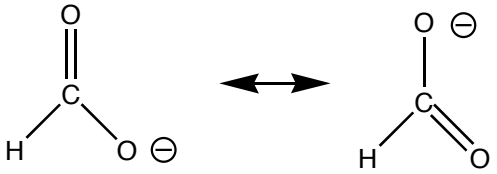
19. What is the formal charge on carbon in CO_3^{2-}?
    a. -2
    b. -1
    c. 0
    d. +2
    e. +1

20. Which describes the relationship between bond strength and bond length as bond order increases?
    a. Both bond strength and bond length increase.
    b. Both bond strength and bond length decrease.
    c. Bond strength decreases and bond length increases.
    d. Bond strength increases and bond length decreases.
    e. None of the above is a relationship between bond strength and bond order.

21. Which molecule is best represented using Lewis resonance structures?
    a. O_2
    b. O_3
    c. PCl_5
    d. SCl_2
    e. CCl_4

22. Predict the carbon-oxygen bond lengths in the formate ion given this information and the structures for the ion.

Carbon-to-Oxygen Bond	Bond Length, pm
triple	109
double	123
single	143

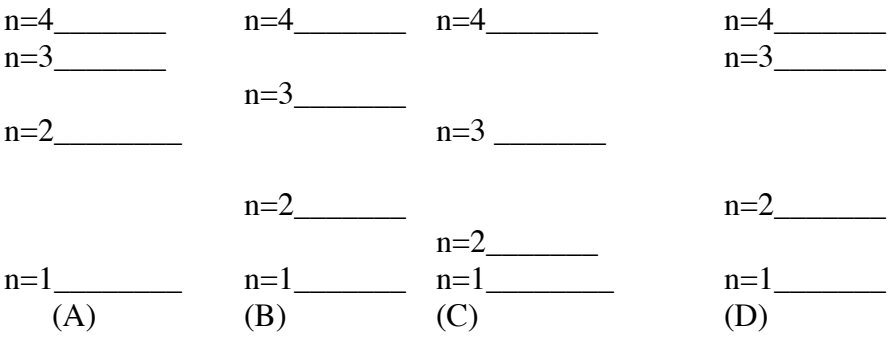


    a. Both carbon-to-oxygen bond lengths are the same and intermediate between 143 pm and 123 pm.
    b. Both carbon-to-oxygen bond lengths are the same and intermediate between 123 pm and 109 pm.
    c. Both carbon-to-oxygen bond lengths are 123 pm.
    d. Both carbon-to-oxygen bond lengths are 143 pm.
    e. Both carbon-to-oxygen bond lengths are 109 pm

23. Light having a frequency of 6×10^{14} s^{-1} has a wavelength of
    a. 5×10^{-7} nm
    b. 50 nm
    c. 500 nm
    d. 500 Å
    e. none of these

24. Which molecule is polar?
    a. SF_6
    b. CF_4
    c. NF_3
    d. PF_5
    e. BF_3

25. Which diagram best represents the distribution of energy levels for the electron in a hydrogen atom?



    a. A
    b. B
    c. C
    d. D
    e. None of the above represents a qualitative distribution of the energy levels for the hydrogen atom.

26. What is the energy of a photon of light having a wavelength of 892.3 nm?
    a. 5.912×10^{-31} J
    b. 2.226×10^{-28} J
    c. 1.773×10^{-22} J
    d. 2.226×10^{-19} J
    e. none of these

27. The electron configuration for Na^+ is
    a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
    b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
    c. $1s^2 2s^2 2p^6 3s^1$
    d. $1s^2 2s^2 2p^6$
    e. $1s^2 2s^2 2p^6 3s^2 3p^6$

28. When two atoms combine and form a covalent bond, the resulting stable molecule
    a. has an energy that may be higher or lower than the two atoms, depending on the molecule.
    b. has lower energy than the two separated atoms.
    c. has higher energy than the two separated atoms.
    d. has the same energy as the two separated atoms.
    e. all of the above statements are correct.

29. Which bond is most polar?
    a. C-O
    b. C-S
    c. C-N
    d. C-H
    e. C-C

30. At STP, what is the volume of fluorine gas which reacts with excess nitrogen gas to produce 5.00 L of nitrogen trifluoride gas according to this equation?
    $H_2(g) + 3F_2(g) \rightarrow 2NF_3(g)$

    a. 15.0 L
    b. 10.0 L
    c. 7.50 L
    d. 1.00 L
    e. 1.50 L

31. When the equation $Fe_2(C_2O_4)_3(s) \rightarrow FeC_2O_4(s) + CO_2(g)$ is balanced using the smallest whole numbers, the coefficient of CO_2 is
    a. 6

    b. 4
    c. 2
    d. 1
    e. 3

32. An electron in which of these orbitals would have the highest energy in a multi-electron atom?

a. 4*s*
b. 4*p*
c. 4*d*
d. 4*f*
e. all of these orbitals have the same energy in a multielectron atom

33. If the empirical formula for a compound is HO, which molecular formula is not possible based on this information alone?

a. H_3O_3
b. H_2O_2
c. H_2O
d. HO
e. H_4O_4

34. Consider the reaction of hydrogen with oxygen to form water

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

If 3.0 mol H_2 react with 2.0 mol O_2, how much water is produced, and what is left over after the reaction is completed?

	Water Produced	Reactant Left Over
a.	5.0 mol	No reactants left over
b.	3.0 mol	0.5 mol O_2
c.	2.0 mol	1.0 mol H_2
d.	1.0 mol	1.0 mol O_2
e.	3.0 mol	No reactants left over

35. Which species has 23 electrons?

a. ^{23}Na
b. ^{44}Sc
c. $^{51}V^{2+}$
d. $^{56}Fe^{3+}$
e. $^{56}Fe^{2+}$

36. Which electronic configuration corresponds to the silicon atom, Si, in the ground state?

a. $1s^2 2s^2 2p^6 2d^2 3s^2$
b. $1s^2 2s^2 2p^6 3s^2 3p^2$
c. $1s^2 2s^2 2p^6 2d^{10} 3s^2 3p^6$
d. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$
e. $1s^2 2s^2 2p^6 2d^{10}$

37. What is the best description of predicted shape of the OF_2 molecule?
    a. bent
    b. linear
    c. tetrahedral
    d. triangular
    e. planar

38. A compound containing only carbon and hydrogen is found to have an empirical formula with molar mass of 13.0 $g.mol^{-1}$. The molecular formula of the compound
    a. could be C_2H_2, but not C_6H_6.
    b. could be C_6H_6, but not C_2H_2
    c. could be either C_2H_2 or C_6H_6
    d. cannot be either C_2H_2 or C_6H_6
    e. There is not enough information provided to decide on the molecular formula

39. Which statement about balanced chemical equations is *false?*
    a. The net charge of the reactants must equal the net charge of the products
    b. The total mass of the reactants must equal the total mass of the products.
    c. The total number of atoms in the reactants must equal the total number of atoms in the products.
    d. The total number of moles of reactants must equal the total number of moles of products.
    e. All of the above statements are correct.

40. A reaction of phosphorus and sulfur is $8P_4(s) + 3S_8(s) \rightarrow 8P_4S_3(s)$
    a. 4.17%
    b. 12.5%
    c. 16.7%
    d. 66.7%
    e. 75%

41. Consider this equation. $3CO(g) + 7H_2(g) \rightarrow C_3H_8(g) + 3H_2O(g)$
What volume of C_3H_8 will be produced if 0.50 L of CO and 1.0 L of H_2 are allowed to react completely? Assume all gases are measured at the same temperature and pressure
    a. 0.060 L
    b. 0.070 L
    c. 0.14 L
    d. 0.17 L
    e. 0.28 L

42. In which of the following diatomic molecules is the bond order equal to 3?
    a. N_2
    b. CO
    c. CN^-
    d. All of the above
    e. None of the above

43. Which electron configuration is incorrect?
    a. $F_2 : (\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2pz})^2(\pi_{2p})^4(\pi^*_{2p})^4$
    b. $N_2 : (\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2 (\pi_{2p})^4(\sigma_{2pz})^2$
    c. $O_2 : (\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2 (\sigma_{2pz})^2$
    d. more than one is incorrect
    e. all are correct

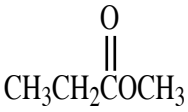
44. Which atom has exactly 4 electrons in its 4p shell?
    a. P
    b. S
    c. Se
    d. Br
    e. Sb

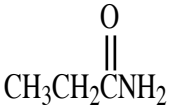
45. The ability of an atom to compete for electrons with another atom to which it is bonded is best described as…
    a. electron affinity
    b. ionization potential
    c. electronegativity
    d. paramagnetism
    e. diamagnetism

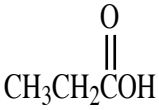
46. What is the number of hydrogen atoms in the hydrocarbon n-pentane?
    a. 4
    b. 8
    c. 10
    d. 12
    e. 6

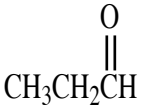
47. Isobutane differs from n-butane in that the former
    a. has a higher molecular weight.
    b. has a different percentage composition
    c. is not a saturated hydrocarbon
    d. has a different empirical formula
    e. has a different structural formula.

48. An example of a ketone is

a. 

b. 

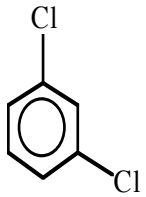
c. 

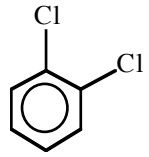
d. 

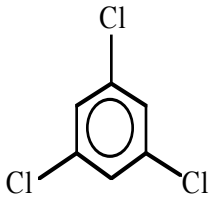
e. None of these structures correspond to a ketone

49. Which of the following benzenes deriviatives possess zero dipole moment?

(A) 

(C) 

(B) 

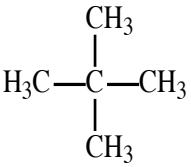
(D) 

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

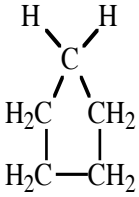
50. Which of the following straight chain hydrocarbons contains at least one double bond?

a. C_5H_{10}
b. C_7H_{16}
c. C_6H_{14}
d. C_2H_6
e. C_3H_8

51. Which of the structures is an isomer of n-pentane?

(A) 

(C) $CH_3(CH_2)_5CH_3$

(B) 

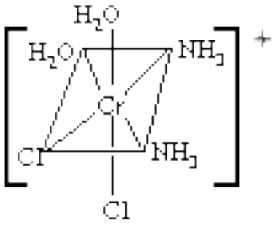
(D) $CH_2{=}CHCH_2CH_2CH_3$

a. A
b. B
c. C
d. D
e. None of the structures is an isomer of n-pentane

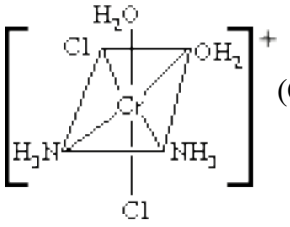
52. Which complex could have cis-trans isomers?

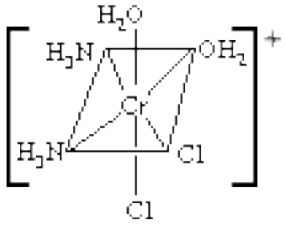
a. square planar $[PtBrCl_3]^{2-}$
b. octahedral $[Fe(CN)_6]^{3-}$
c. tetrahedral $[ZnBrCl_3]^{2-}$
d. octahedral $[CrBr_2(NH_3)_4]^{+}$
e. None of these complexes could have cis-trans isomers

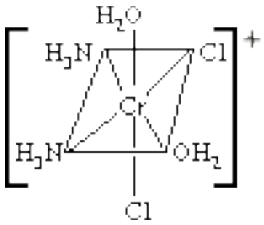
53. Which of the structures A, B, C or D is the optical isomer of the complex ion 1?

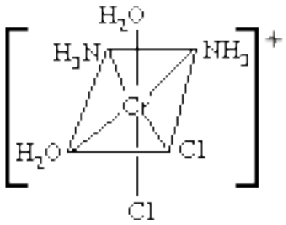


Complex ion 1

(A) 

(C) 

(B) 

(D) 

a. A
b. B
c. C
d. D
e. None of these structures is the optical isomer of the complex

54. What is the geometry of the complex ion $[CoF_6]^{3-}$?

a. Tetrahedral
b. Square planar
c. Octahedral
d. Trigonal bipyramidal
e. Hexagonal

55. A compound has the empirical formula $CoCl_3 \cdot 4NH_3$. One mole of the compound yields one mole of silver chloride when treated with silver nitrate. Ammonia is not removed by treatment with concentrated sulfuric acid. The formula for the compound is best represented by
    a. $Co(NH_3)_4Cl_3$
    b. $[Co(NH_3)Cl_2]Cl$
    c. $[Co(NH_3)_3Cl_3]NH_3$
    d. $[Co(NH_3)_4Cl_2]Cl$
    e. None of these formulae are consistent with the reaction with silver nitrate.

56. The oxidation state of V in $[V(NH_3)_4Cl_2]$ is ____, while that of Mo in $[Mo_2Cl_8]^{4-}$ is ____.
    a. 0, 0
    b. 0, 2
    c. 2, 2
    d. 2, 4
    e. 6, 4

57. Optical isomers can be distinguished by their
    a. chemical properties.
    b. different rotations of plane polarized light.
    c. polarity.
    d. boiling point.
    e. color.

58. Which of the following will show the greatest energy increase when six ligands approach the central atom along the *x*, *y*, and *z* axes?
    a. d_{xy}
    b. d_{yz}
    c. d_{z^2}
    d. d_{xz}
    e. They should all be the same.

59. In a strong octahedral field, where Δ_0 is large, Mn^{3+} will have ___ unpaired electrons.
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5

60. According to crystal-field theory, the frequency of electromagnetic radiation that can be absorbed by a metal ion in an octahedral complex is given by
    a. $\nu = h\Delta_0$
    b. $\nu = \frac{h}{\Delta_0}$
    c. $\nu = \frac{\Delta_0}{h}$
    d. $\nu = h + \Delta_0$
    e. none of these

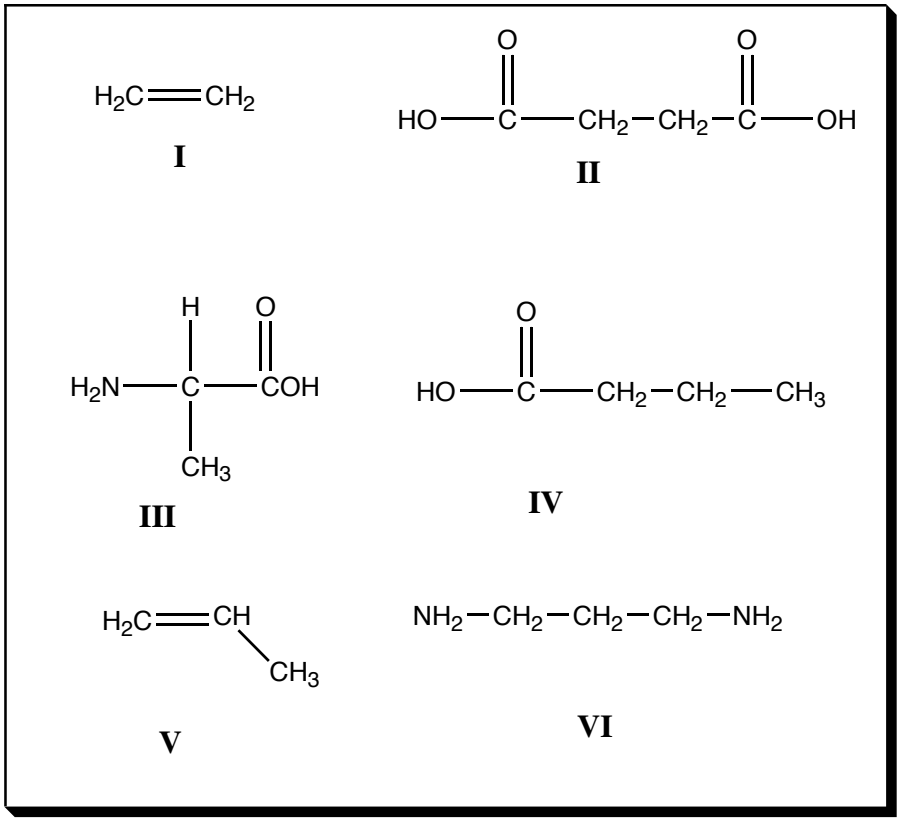
61. Rank the following ligands in order of increasing strength of interaction with the central metal ion:
    I^-, OH^-, H_2O, NH_3
    a. $I^- < OH^- < H_2O < NH_3$
    b. $NH_3 < OH^- < H_2O < I^-$
    c. $NH_3 < OH^- < I^- < H_2O$
    d. $OH^- < H_2O < NH_3 < I^-$
    e. none of these

62. Vinyl chloride (C_2H_3Cl) undergoes addition polymerization to give a high molecular mass polymer. The best empirical formula for this product is
    a. CH_3Cl
    b. C_2H_2
    c. C_2H_3
    d. C_2H_3Cl
    e. C_2HCl_2

63. Amino acids link to form proteins by means of
    a. hydrogen bonding.
    b. condensation polymerization.
    c. addition polymerization.
    d. alpha helix extension.
    e. none of these.

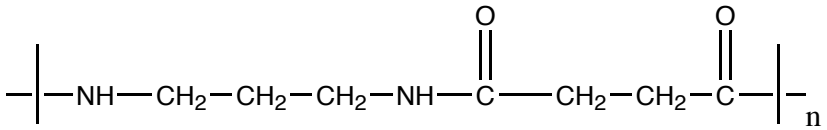
64. When butadiene ($H_2C=CH-CH=CH_2$) polymerizes to polybutadiene, the molecules of polymer have an average of how many double bonds per monomer unit?
    a. 0
    b. 1/2
    c. 1
    d. 3/2
    e. 2

Use the structures below to answer questions 65, 66 and 67.



65. Which monomer is most likely found in biological systems?
    a. I
    b. III
    c. IV
    d. VI
    e. II

66. Which two monomers could react to form this polymer?



    a. II and VI
    b. III and IV
    c. III and VI
    d. IV and VI
    e. III and II

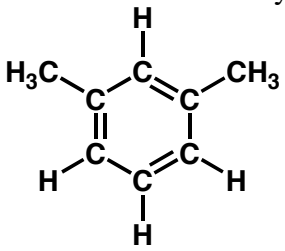
67. Which monomer could react to produce a protein?
   a. I
   b. II
   c. III
   d. IV
   e. VI

68. Determine whether O_2^+ has a (longer, shorter) bond length and therefore a (higher, lower) bond energy than O_2:
   a. longer, lower
   b. longer, higher
   c. shorter, higher
   d. shorter, lower
   e. There is no difference in length

69. How many sigma and pi bonds are to be found in HCN?
   a. 1 σ and 1 π
   b. 1 σ and 2 π
   c. 1 σ and 3 π
   d. 2 σ and 1 π
   e. 2 σ and 2 π

70. If the ethylene molecule gains an additional electron to give the molecular anion, $C_2H_4^-$, then the bond order can be expected to (increase, decrease) and the C-to-C stretching frequency in the infrared can be expected to (increase, decrease):
   a. increase, increase
   b. increase, decrease
   c. decrease, increase
   d. decrease, decrease
   e. No change

71. How many peaks will appear in the 13C NMR spectrum of 1,3-dimethylbenzene?



   a 1
   b 2
   c 3
   d 4
   e 5

72. Which of the following molecules best fits the IR spectrum?

a $(CH_3)_2C=C(CH_3)_2$

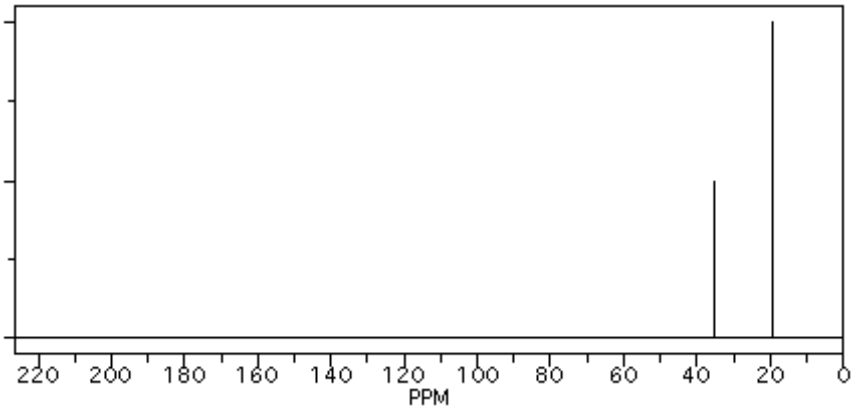
b $CH_3CH_2CH_2CH_2CH_2CH_3$

c $HC\equiv CCH_2CH_2CH_2CH_2CH_3$

d Both A and B are possible

e None of the above

73. Which of the following molecules best fits the ^{13}C-NMR spectrum?



a $(CH_3)_2C=C(CH_3)_2$

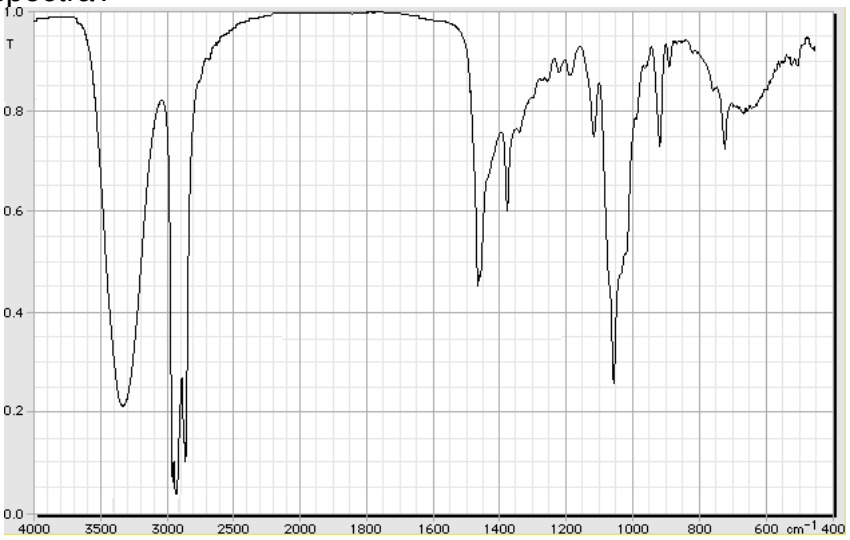
b $CH_3CH_2CH_2CH_2CH_2CH_3$

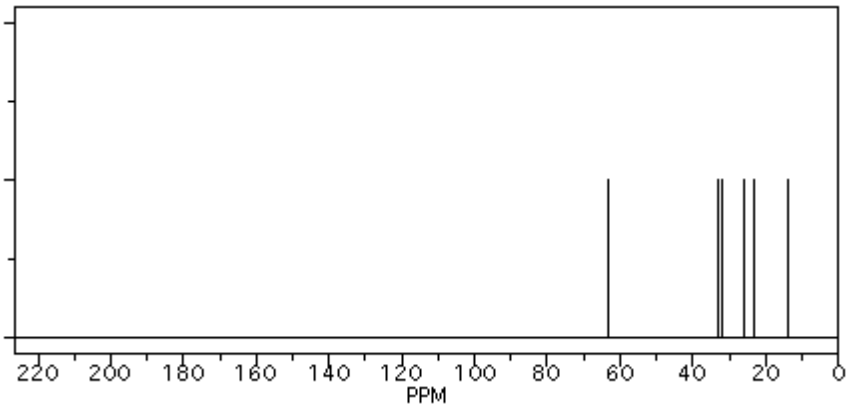
c $HC\equiv CCH_2CH_2CH_2CH_2CH_3$

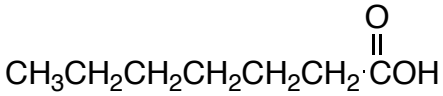
d Both A and B are possible

e None of the above

74. Which of the following molecules best fits both the 13C and the IR spectra?





a 

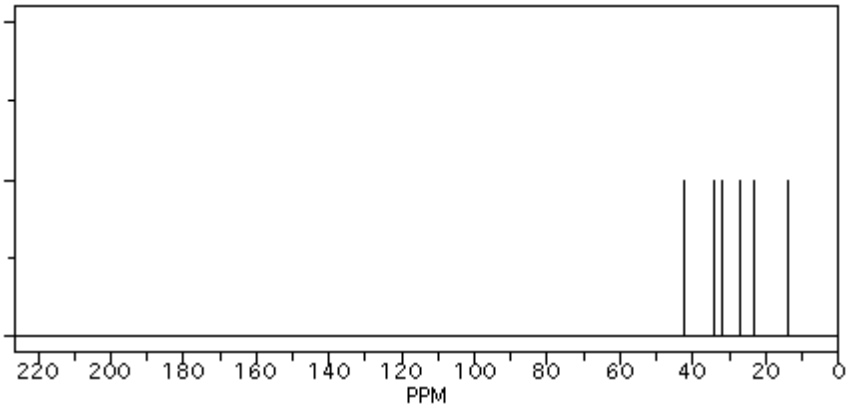
b $CH_3CH_2CH_2CH_2CH_2CH_3$

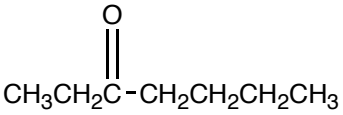
c $HC{\equiv}CCH_2CH_2CH_2CH_2CH_3$

d $CH_3CH_2CH_2CH_2CH_2CH_2\text{-}NH_2$

e $CH_3CH_2CH_2CH_2CH_2CH_2\text{-}OH$

75. Which of the following molecules best fits the spectra?



a 

b $(CH_3)_2C{=}C(CH_3)_2$

c $CH_2{=}CHCH_2CH_2CH_2CH_3$

d $CH_3CH_2CH_2CH_2CH_2CH_2\text{-}NH_2$

e None of the above