



- 1) What types of isomerism could the compound  $[\text{Cr}(\text{en})_2(\text{Cl})_2]\text{Br}$  display? Assume the compound has an octahedral or tetrahedral geometry. (3 pts)
- geometrical, optical
  - coordination, geometrical, optical**
  - coordination, geometrical
  - coordination, geometrical, linkage
  - linkage, geometrical, coordination, optical
- 2) What types of isomerism could the compound  $\text{Mn}(\text{NH}_3)_2(\text{Cl})_2$  display? Assume the compound has an octahedral or tetrahedral geometry. (3 pts)
- coordination
  - geometrical
  - coordination, geometrical, optical
  - geometrical, optical
  - no isomerism is present**
- 3) What types of isomerism could the square planar compound  $\text{Pt}(\text{NH}_3)_2(\text{SCN})(\text{Cl})$  display? (3 pts)
- geometrical, linkage**
  - coordination, linkage
  - geometrical, linkage, optical
  - geometrical, optical
  - coordination, geometrical, linkage, optical
- 4) Give the name for the compound  $[\text{Cr}(\text{en})_2(\text{NH}_3)_2]\text{Cl}_3$  (3 pts)
- diamminebis(ethylenediamine)chromium(III) chloride**
  - diamminedi(ethylenediamine)chromium(V) chloride
  - diamminebis(ethylenediamine)chromium(V) chloride
  - diamminedi(ethylenediamine)chromium(III) chloride
  - diamminebis(ethylenediamine)chromium(II) chloride
- 5) Give the name for the compound  $\text{Na}[\text{Cu}(\text{OH})_3(\text{CO})]$  (3 pts)
- sodium triaquacarbonylcopper(III)
  - sodium triaquacarbonylcopper(II)
  - sodium triaquacarbonylcuprate(III)
  - sodium carbonyltrihydroxocopper(II)
  - sodium carbonyltrihydroxocuprate(II)**

- 6) If the complex ion  $\text{Cr}(\text{H}_2\text{O})_6^{3+}$  appears violet, what color could  $\text{Cr}(\text{OH})_6^{3-}$  appear? (4 pts)
- red
  - orange
  - blue**
- 7) Select the complex ion that will not absorb light. (4 pts)
- $[\text{Co}(\text{en})_2(\text{H}_2\text{O})_2]^{2+}$
  - $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$
  - $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$**
  - $[\text{Fe}(\text{CO})_4]^{2+}$
- 8) Of the following complex ions, two appear violet in aqueous solution, one appears red, one appears blue-green, and one appears yellow. Which of the following appears yellow? (4 pts)
- $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$
  - $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]^{2+}$
  - $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$
  - $[\text{Cr}(\text{NH}_3)_6]^{3+}$**
  - $[\text{Cr}(\text{NH}_3)_5\text{Cl}]^{2+}$
- 9) How many unpaired electrons does the compound  $\text{Fe}(\text{en})_2(\text{CN})_2$  have? Assume the compound has an octahedral or tetrahedral geometry. (4 pts)
- 0**
  - 1
  - 2
  - 3
  - 4

- 10) Choose the complex ion with two unpaired electrons. All complex ions have an octahedral or tetrahedral geometry. (6 pts)
- a)  $\text{Cr}(\text{Br})_6^{4-}$
  - b)  $\text{Cr}(\text{CO})_6^{2+}$
  - c)  $\text{Fe}(\text{CN})_4^{2-}$
  - d) None of the above
- 11) What is the boiling point of a 2.5 molal aqueous solution of  $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_2$ ? The boiling point elevation constant for water is  $0.51^\circ\text{C kg mol}^{-1}$ . Assume complete dissociation of any soluble salts. (5 pts)
- a)  $102.6^\circ\text{C}$
  - b)  $101.3^\circ\text{C}$
  - c)  $3.8^\circ\text{C}$
  - d)  $103.8^\circ\text{C}$
  - e)  $111.5^\circ\text{C}$
- 12) A mixture of benzene and an unknown volatile liquid has a vapor pressure of 165 torr at  $25^\circ\text{C}$  when the mole fraction of benzene is 0.25. What is the vapor pressure of the pure unknown compound? At  $25^\circ\text{C}$ , the vapor pressure of pure benzene is 100.84 torr. Assume the solution is ideal. (5 pts)
- a) 357 torr this answer worth 2 pts
  - b) 186 torr
  - c) 157 torr
  - d) 89.8 torr
  - e) 122 torr

- 13) Which of the following will have the highest boiling point at 1.0 atm? (5 pts)
- a) pure water
  - b) a 0.10 m solution of calcium chloride ( $\text{CaCl}_2$ ) in water
  - c) a 0.10 m solution of potassium phosphate ( $\text{K}_3\text{PO}_4$ ) in water
  - d) **a 0.25 m solution of sodium permanganate ( $\text{NaMnO}_4$ ) in water**
  - e) a 0.30 m solution of acetone ( $\text{CH}_3\text{COCH}_3$ ) in water
- 14) Select the molecule which forms a molecular solid. (3 pts)
- a)  $\text{MgCl}_2$
  - b) Ne
  - c)  $\text{Ca}_2[\text{Cr}(\text{Cl})_6]$
  - d)  **$\text{H}_2\text{CO}$**
- 15) Which molecule would you expect to have the lowest  $\Delta H_{\text{vap}}$ ? (3 pts)
- a) hexane
  - b) **pentane**
  - c)  $\text{H}_2\text{O}$
  - d)  $\text{HOCH}_2\text{OH}$
  - e) acetone ( $\text{CH}_3\text{COCH}_3$ )
- 16) Which molecule would you expect to have the lowest vapor pressure? (3 pts)
- a) hexane
  - b) pentane
  - c)  $\text{H}_2\text{O}$
  - d)  **$\text{HOCH}_2\text{OH}$**
  - e) acetone ( $\text{CH}_3\text{COCH}_3$ )
- 17) Which molecule would you expect to have the highest boiling point? (3 pts)
- a) hexane
  - b) pentane
  - c)  $\text{H}_2\text{O}$
  - d)  **$\text{HOCH}_2\text{OH}$**
  - e) acetone ( $\text{CH}_3\text{COCH}_3$ )

- 18) The normal boiling point of acetone is  $56.2^{\circ}\text{C}$  and the molar heat of vaporization is  $32.0\text{ kJ/mol}$ . At what temperature will acetone boil when it is held under a pressure of  $35.0\text{ torr}$ ? (5 pts)
- a)  $0.0038^{\circ}\text{C}$
  - b)  **$-12.5^{\circ}\text{C}$**
  - c)  $-182^{\circ}\text{C}$
  - d)  $1.24^{\circ}\text{C}$
  - e)  $53.8^{\circ}\text{C}$
- 19) A  $2.52\text{ Molar}$  aqueous solution of glucose was prepared by adding  $100\text{ mL}$  of water to  $50\text{ g}$  of glucose, which had a final volume of  $131\text{ mL}$ . What is the molality of this solution? Assume the density of pure water is  $1.00\text{ g/mL}$ . (5 pts)
- a)  $2.52\text{ m}$
  - b)  $0.330\text{ m}$
  - c)  $1.92\text{ m}$
  - d)  **$3.30\text{ m}$**
  - e)  $19.2\text{ m}$
- 20) The solubility of  $\text{N}_2$  in blood is  $5.9 \times 10^{-4}\text{ mol/L}$  at  $37^{\circ}\text{C}$  and normal atmospheric pressure (where the partial pressure of  $\text{N}_2$  is  $0.80\text{ atm}$ ). Deep-sea divers experience a condition called nitrogen narcosis when the partial pressure of  $\text{N}_2$  in the compressed air they're breathing reaches  $4.0\text{ atm}$ , which results in the divers feeling like they're tipsy. What is the concentration of dissolved nitrogen in the blood when a diver begins to experience nitrogen narcosis? (6 pts)
- a)  **$3.0 \times 10^{-3}\text{ mol/L}$**
  - b)  $1.2 \times 10^{-4}\text{ mol/L}$
  - c)  $1.8 \times 10^{-4}\text{ mol/L}$
  - d)  $2.6 \times 10^{-3}\text{ mol/L}$
  - e)  $5.9 \times 10^{-4}\text{ mol/L}$

- 21) The triple point on the phase diagram for an unknown compound is located at 0.53atm and 15.0°C, and the critical point is located at 156atm and 230°C. At which constant temperature could both a solid→liquid and liquid→gas phase change occur as the pressure is decreased?

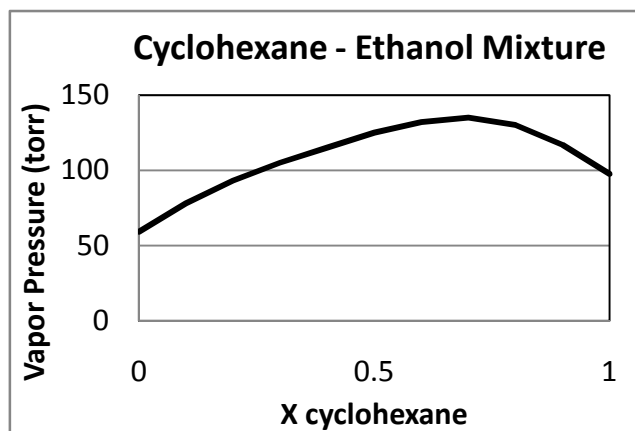
Assume that the density of the solid state is greater than the liquid state for unknown compound, and that there are only three phases represented on the diagram. (5 pts)

- a) 0°C
- b) 15.0°C
- c) **20°C**
- d) 260°C
- e) There is no such temperature where both phase changes could occur.

- 22) The vapor pressures of several solutions of cyclohexane and ethanol were determined at various compositions at 25°C. A plot of vapor pressure vs. mole fraction of cyclohexane is shown at right. (4 pts)

Does this solution follow Raoult's Law?

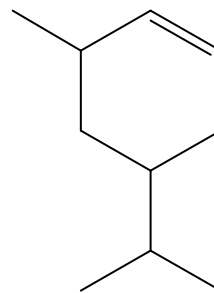
- a) Yes
- b) **No, it has a positive deviation**
- c) No, it has a negative deviation



- 23) Consider the cyclohexane-ethanol mixture described in the previous problem. As you mix cyclohexane and ethanol together, will you notice a temperature change? (4 pts)
- a) No, there will be no temperature change
  - b) Yes, the mixture will feel warmer than before mixing.
  - c) **Yes, the mixture will feel colder than before mixing**
- 24) Consider the cyclohexane-ethanol mixture described in the previous problems. Which would be the strongest? (4 pts)
- a) **The interactions between ethanol molecules in the pure solvent**
  - b) The interactions between cyclohexane molecules in the pure solvent
  - c) The interactions between cyclohexane and ethanol molecules in the mixture

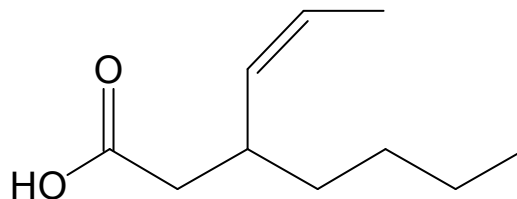
25) Give the systematic name of the compound at right. (4 pts)

- a) 4-isopropyl-2-methyl-1-cyclohexene
- b) 1-isopropyl-3-methyl-4-cyclohexene
- c) **5-isopropyl-3-methylcyclohexene**
- d) 4-isopropyl-6-methylcyclohexene
- e) 4-isopropyl-2-methylcyclohexene



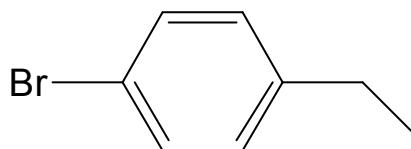
26) Give the systematic name of the compound at right. (4 pts)

- a) *cis*-3-butyl-4-pentenoic acid
- b) ***cis*-3-butyl-4-hexenoic acid**
- c) *cis*-3-propylheptanoic acid
- d) *trans*-3-propylheptanoic acid
- e) *trans*-3-butyl-4-hexenoic acid



27) Give the systematic name of the compound at right. (4 pts)

- a) ***p*-bromoethylbenzene**
- b) *p*-methylbromobenzene
- c) *m*-bromoethylbenzene
- d) *o*-ethylbromobenzene
- e) *o*-bromomethylbenzene



28) Draw the structure of 2-propyl-4,4-dimethylhexane. Is there a better name for this compound? (5 pts)

- a) no, 2-propyl-4,4-dimethylhexane is correct
- b) yes, 2-ethyl-2,4-dimethylheptane
- c) yes, 4,6,6-trimethyloctane - keep this one second or third
- d) yes, 3,3,5-trimethylheptane
- e) **yes, 3,3,5-trimethyloctane**

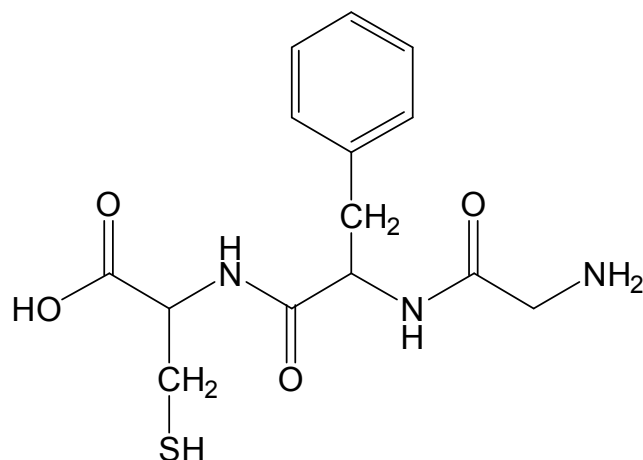
29) Which of the following is not a structural isomer of 1-pentanol? (5 pts)

- a) 3-methyl-1-butanol
- b) **2-methylbutanal**
- c) 3-pentanol
- d) **2-methyl-1-propanol**
- e) 2,2-dimethyl-1-propanol

**both answers are correct**

30) What is the amino acid sequence of the following tripeptide? (5 pts)

- a) asn-phe-ser  
 b) **cys-phe-gly** This answer 3 pts  
 c) cys-phe-asn  
 d) ser-phe-gly  
 e) **gly-phe-cys**



For Reference:

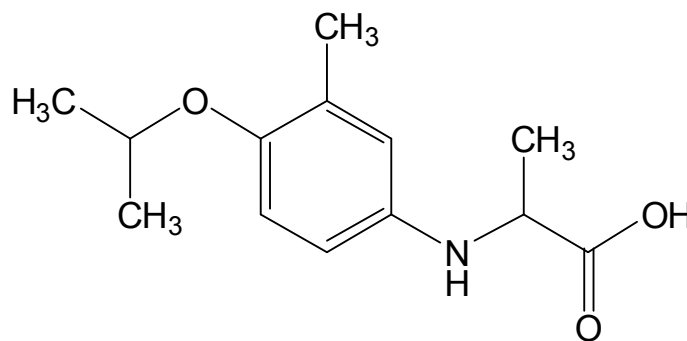
- Gly -H  
 Ala -CH<sub>3</sub>  
 Phe -CH<sub>2</sub>-phenyl  
 Asn -CH<sub>2</sub>-(C=O)-NH<sub>2</sub>  
 Cys -CH<sub>2</sub>-SH  
 Leu -CH<sub>2</sub>-CH-(CH<sub>3</sub>)<sub>2</sub>  
 Ser -CH<sub>2</sub>-OH

31) Select the amino acid that will not rotate plane-polarized light. The R groups of are listed above. (4 pts)

- a) Glutamic acid (gln)  
 b) **Glycine (gly)**  
 c) Cysteine (cys)  
 d) Serine (ser)  
 e) Alanine (ala)

32) Which functional groups are present in the molecule at right? (5 pts)

- a) phenol, amine, carboxylic acid  
 b) ester, amine, carboxylic acid  
 c) **ether, amine, carboxylic acid**  
 d) amine, aldehyde  
 e) ester, aldehyde



33) How many chiral carbons are present in the molecule given in problem 32 above? (5 pts)

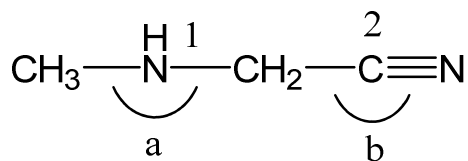
- a) 0                      **b) 1**                      c) 2                      d) 3                      e) 4

- 34) Which molecule has the highest melting point? (4 pts)
- 4-chloro-2-pentene
  - 2-pentene
  - 2-methylpentanal
  - 3-chloropentanoic acid**
  - 3-chloro-2-pentanone
- 35) What is the dominant intermolecular force present in propanal? (4 pts)
- Hydrogen bonding
  - Dipole-dipole forces**
  - Dispersion forces
  - No intermolecular forces are present
- 36) What is the electron configuration of the molecular orbitals in the carbide ion,  $C_2^{2-}$ ? List the molecular orbitals in order of increasing energy. (4pts)
- $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\sigma_{2p})^2 (\pi_{2p})^4$
  - $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\sigma_{2p})^4$
  - $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^1$
  - $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4$
  - $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2$**
- 37) Based on molecular orbital theory, which would have the stronger bond,  $C_2^{2-}$  or  $N_2$ ? (3 pts)
- $N_2$  will have the stronger bond
  - $C_2^{2-}$  will have the stronger bond
  - The bond strengths will be equal**
- 38) Based on molecular orbital theory, which has the lowest bond order? (3 pts)
- a)  $C_2^{2-}$       b)  $N_2$       c)  $CN^-$       **d)  $N_2^{2-}$**
- 39) Based on molecular orbital theory, which of the following is paramagnetic? (3 pts)
- a)  $C_2^{2-}$       b)  $N_2$       c)  $CN^-$       **d)  $N_2^{2-}$**

The following four questions are all about the same molecules,  $\text{SO}_3$ ,  $\text{XeF}_4$ ,  $\text{PCl}_3$  and  $\text{PH}_3$ .

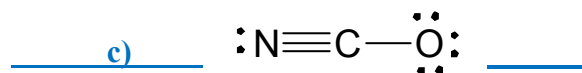
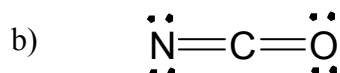
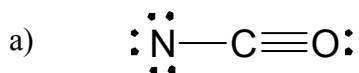
- 40) Which of the following has a trigonal planar geometry? (4 pts)  
 a)  $\text{PCl}_3$       b)  $\text{PH}_3$       c)  **$\text{SO}_3$**       d)  $\text{XeF}_4$
- 41) Which of the following has a square planar geometry? (4 pts)  
 a)  $\text{PCl}_3$       b)  $\text{PH}_3$       c)  $\text{SO}_3$       d)  **$\text{XeF}_4$**
- 42) Which of the following is a polar molecule? (4 pts)  
 a)  **$\text{PCl}_3$**       b)  $\text{PH}_3$  \_worth 2pts      c)  $\text{SO}_3$       d)  $\text{XeF}_4$
- 43) Which of the following has a central atom that is  $d^2sp^3$  hybridized? (4 pts)  
 a)  $\text{PCl}_3$       b)  $\text{PH}_3$       c)  $\text{SO}_3$       d)  **$\text{XeF}_4$**

The next four questions concern the following molecule:



- 44) What is the angle labeled (a)? (3 pts)  
 a)  $90^\circ$       **b)  $107^\circ$**       c)  $109.5^\circ$       d)  $120^\circ$       e)  $180^\circ$
- 45) What is the angle labeled (b)? (3 pts)  
 a)  $90^\circ$       b)  $107^\circ$       c)  $109.5^\circ$       d)  $120^\circ$       **e)  $180^\circ$**
- 46) What is the hybridization of the nitrogen atom present as NH, labeled (1) in the diagram above? (3 pts)  
 a)  $sp$       b)  $sp^2$       c)  **$sp^3$**       d)  $dsp^3$       e)  $d^2sp^3$
- 47) What is the hybridization of the carbon atom participating in the triple bond, labeled (2) in the diagram above? (3 pts)  
 a)  **$sp$**       b)  $sp^2$       c)  $sp^3$       d)  $dsp^3$       e)  $d^2sp^3$

- 48) Three possible Lewis structures for the molecule  $\text{NCO}^-$  are shown below. Which is the best / most stable structure? (4 pts)



- 49) Select the molecule with the longest nitrogen-nitrogen bond. Hint: all molecules actually contain a nitrogen-nitrogen bond. (5 pts)



- 50) Consider the molecule shown below. How many atoms lie in the same plane? (4 pts)

