

SIC 102  
Final Exam

1. (15 points) Using a line-angle drawing or a structural formula, draw the structures of the following molecules.

a) 2,2-dimethyl-3-hexyne

b) 3-ethyl-3-pentanol

c) triethylamine

d) 3-methyl-2-butanone

e) phenyl butanoate

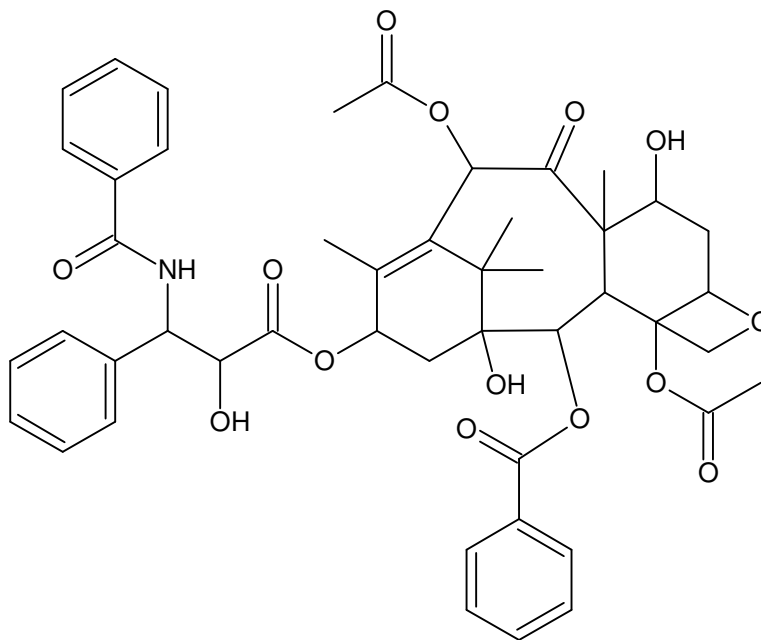
2. (10 points) The following are data for a few chemical substances:

Compound	Structure	mp (°C)	bp (°C)
2-propanol	$\begin{array}{c} \text{OH} \\   \\ \text{H}_3\text{C}-\text{CH}-\text{CH}_3 \end{array}$	-88.5	82.4
2-propanone	$\begin{array}{c} \text{O} \\    \\ \text{H}_3\text{C}-\text{C}-\text{CH}_3 \end{array}$	-94.3	56.2
2-methylpropene	$\begin{array}{c} \text{CH}_2 \\    \\ \text{H}_3\text{C}-\text{C}-\text{CH}_3 \end{array}$	-140.3	-6.9

Explain the trends in melting point and boiling point in terms of intermolecular interactions.

3. (15 points) Using a line-angle drawing or structural formula, draw three isomers with the formula  $\text{C}_4\text{H}_{10}\text{O}$ . Provide an unambiguous systematic name for each isomer.

4. (15 points) The compound taxol, shown below, is important in cancer research and treatment. Circle as many functional groups as you can find, and label what kind of functional group they are (alkene, alkyne, aromatic, alcohol, amine, ether, aldehyde, ketone, carboxylic acid, ester, amide). There are 14 functional groups in taxol.



Taxol

5. (10 points) Suppose you have a bottle of distilled water, a bottle of 1 m CaCl<sub>2</sub>, and a bottle of 1 m fructose. Rank these solutions in order of increasing melting point and explain your answer.

6. (20 points) A solution of magnesium hydroxide of unknown concentration is titrated with a standard solution of hydrochloric acid

a) Write a balanced chemical equation for this reaction. Under the equation, identify which species is an acid, which species is a base, which species is the conjugate acid, and which species is the conjugate base.

b) A 25.00 mL sample of magnesium hydroxide reacts with 32.05 mL of 0.1104 M hydrochloric acid. What is the concentration of the magnesium hydroxide solution?

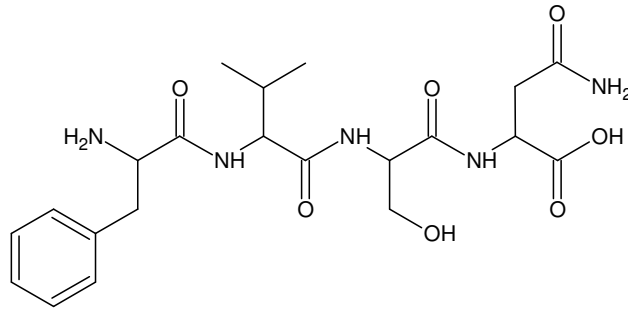
c) What is the pH of the hydrochloric acid solution?

d) What is the concentration of  $[H^+]$  in the magnesium hydroxide solution? Recall that  $K_w = 1.00 \times 10^{-14}$

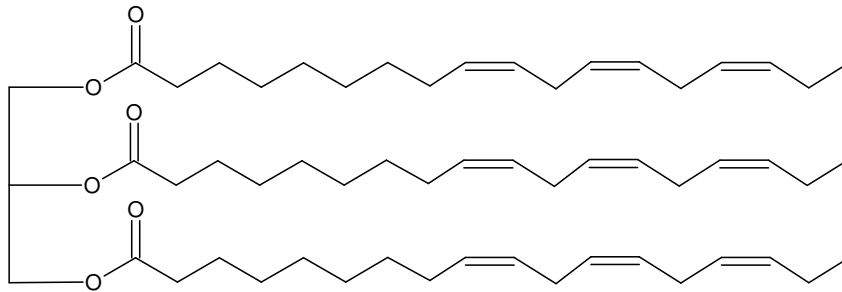
e) What is the pH of the magnesium hydroxide solution?

7. (15 points) For each molecule below, identify whether it is a carbohydrate, lipid, protein, or nucleic acid. If it is a carbohydrate, identify whether it is simple or complex. If it is a lipid, identify what type of lipid it is and whether it is saturated or unsaturated (if applicable). If it is a protein, identify the number of amino acids in it. If it is a nucleic acid, identify whether it is DNA or RNA.

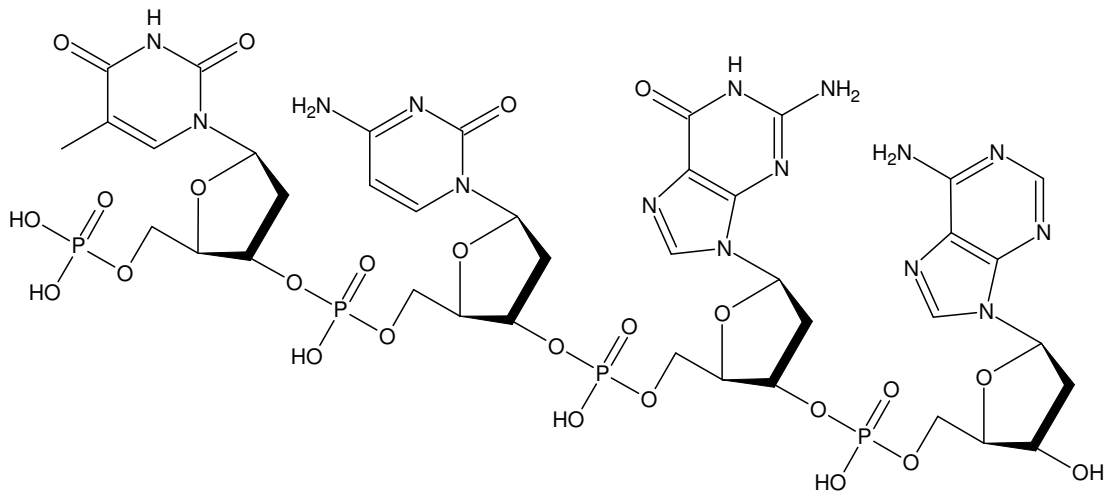
a)



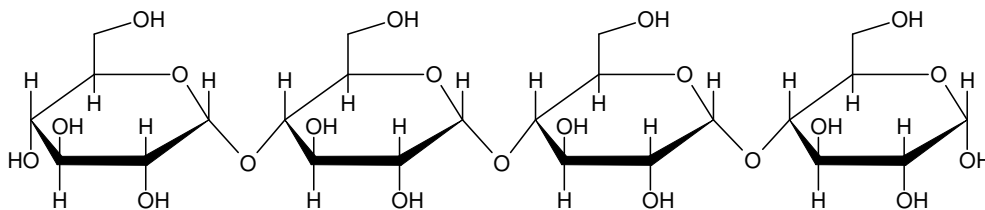
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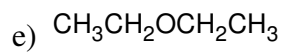
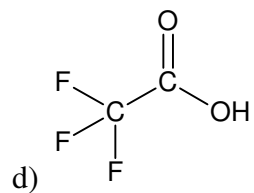
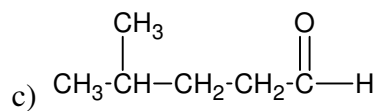
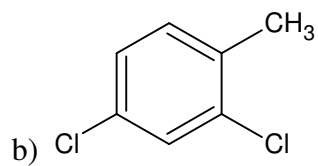
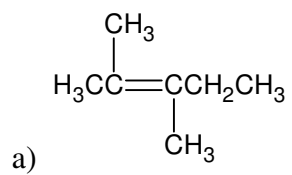
c)



d)



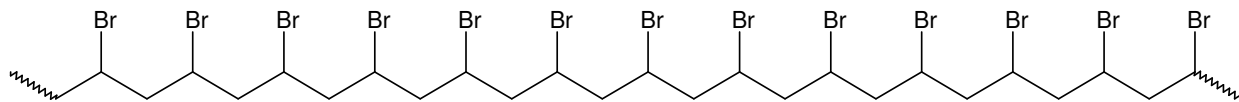
8. (15 points) Provide an unambiguous, systematic name for each compound.





For the remaining questions (5 points each), circle the letter that corresponds to the best answer.

10. Poly(vinyl bromide) is sometimes used for plumbing chemistry labs because the material has a relatively high resistance to common laboratory reagents. A section of PVB polymer is shown below:



Which of the following statements are *true*?

- I. The polymer can be represented as  $[\text{CH}_2\text{CHBr}]_n$ .
- II. The polymer can be represented as  $[\text{CHBrCH}_2\text{CHBr}]_n$ .
- III. The monomer of this polymer is bromoethane.
- IV. The monomer of this polymer is bromoethene.
- V. The monomer of this polymer is bromoethyne.

- (A) **II and III**
- (B) **I and IV**
- (C) **I and III**
- (D) **II and V**
- (E) **I and V**

11. Which of the following functional groups does *not* contain the carbonyl ( $\text{C}=\text{O}$ )?

- (A) ester
- (B) ketone
- (C) ether
- (D) carboxylic acid
- (E) aldehyde

12. Which of the following are conjugate acid/base pairs?

- I.  $\text{HNO}_3$  and  $\text{NO}_3^-$
- II.  $\text{H}^+$  and  $\text{OH}^-$
- III.  $\text{H}_2\text{PO}_4^-$  and  $\text{HPO}_4^{2-}$
- IV.  $\text{C}_5\text{H}_5\text{NH}^+$  and  $\text{C}_5\text{H}_5\text{N}$

- (A) **I and II**
- (B) **II only**
- (C) **I and III**
- (D) **I, III, and IV**
- (E) **II, III, and IV**



For problems 13 - 16, consider the following disturbances to systems at equilibrium and predict the nature of the shift in equilibrium position.

13.  $\text{CaCO}_3(s)$  is added to the system  $\text{CaCO}_3(s) \rightleftharpoons \text{CaO}(s) + \text{O}_2(g)$ .

- (A) The equilibrium will shift left.
- (B) The equilibrium will shift right.
- (C) The equilibrium position will not change.

14. The concentration of  $\text{H}_2(g)$  is increased in the system  $\text{N}_2(g) + 3 \text{H}_2(g) \rightleftharpoons 2 \text{NH}_3(g)$ .

- (A) The equilibrium will shift left.
- (B) The equilibrium will shift right.
- (C) The equilibrium position will not change.

15. The total pressure is increased on the system  $\text{CO}(g) + \text{H}_2\text{O}(g) \rightleftharpoons \text{CO}_2(g) + \text{H}_2(g)$ .

- (A) The equilibrium will shift left.
- (B) The equilibrium will shift right.
- (C) The equilibrium position will not change.

16. The exothermic reaction in the system  $\text{C}_2\text{H}_2\text{N}_4(g) \rightleftharpoons 2 \text{N}_2(g) + \text{C}_2\text{H}_2(g)$  is heated.

- (A) The equilibrium will shift left.
- (B) The equilibrium will shift right.
- (C) The equilibrium position will not change.

17. Which of the following statements is *true*?

- I.** A weak base has a strong conjugate acid
- II.** The strength of an acid is inversely proportional to the affinity of the conjugate base for hydrogen ions
- III.** As base strength increases, the conjugate acid is more willing to donate hydrogen ions.
- IV.** The dissociation equilibrium for a strong acid lies to the right.

- (A) **II** and **III**
- (B) **I**, **II**, and **IV**
- (C) **II** only
- (D) **II** and **IV**
- (E) all of the above

For questions 18 and 19, refer to the activity series shown on the right.

18. Which of the following reactions are spontaneous?

- I.**  $\text{Zn}(s) + \text{Cu}^{2+}(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Cu}(s)$   
**II.**  $\text{Ca}^{2+}(aq) + 2 \text{Ag}(s) \rightarrow \text{Ca}(s) + 2 \text{Ag}^+(aq)$   
**III.**  $\text{Sn}(s) + 2 \text{H}^+(aq) \rightarrow \text{Sn}^{2+}(aq) + \text{H}_2(g)$   
**IV.**  $\text{Ni}^{2+}(aq) + \text{Mn}(s) \rightarrow \text{Ni}(s) + \text{Mn}^{2+}(aq)$   
**V.**  $3 \text{K}^+(aq) + \text{Al}(s) \rightarrow 3 \text{K}(s) + \text{Al}^{3+}(aq)$

- (A) **I** and **V**  
 (B) **I** and **III**  
 (C) **II**, **IV**, and **V**  
 (D) **II**, **III**, and **IV**  
 (E) all of the above

19. Which set of metals will dissolve in acid?

- (A) Na, Sn, and Fe  
 (B) Mg, Cu, and Cr  
 (C) Au, Cu, and Ag  
 (D) Mg, Mn, and Ag  
 (E) Ca, Cu, and Cr

20. A solution of 10.0 g of NaCl in a total volume of 100 mL of water has a concentration of:

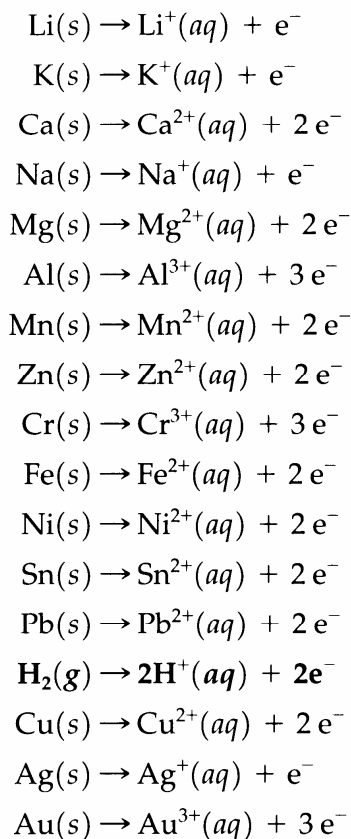
- (A) 10.0% by mass  
 (B) 1.71 M  
 (C) all of the above  
 (D) none of the above

21. Which one of these reagents is *not* a strong acid?

- (A) nitric acid  
 (B) sulfuric acid  
 (C) hydrochloric acid  
 (D) acetic acid

**TABLE 16.1**

**Activity Series of Metals**



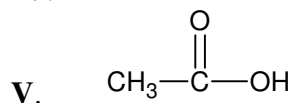
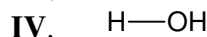
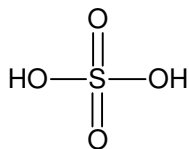
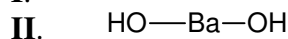
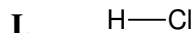
22. Which of the following functional groups does *not* contain a double bond?

- (A) ketone
- (B) alkane
- (C) ester
- (D) carboxylic acid
- (E) alkene

23. How many neutrons, protons, and electrons are in iodine-131?

- (A) 53 neutrons, 78 protons, 53 electrons
- (B) 131 neutrons, 53 protons, 53 electrons
- (C) 78 neutrons, 53 protons, 53 electrons
- (D) 78 neutrons, 53 protons, 78 electrons
- (E) 78 neutrons, 131 protons, 131 electrons

24. Which of the following compounds will produce a solution with  $\text{pH} < 7$ ?



- (A) **I** and **III**
- (B) **I** and **V**
- (C) **II** and **IV**
- (D) **I**, **III**, and **V**
- (E) all of the above

25. Which of the following alkane names is unambiguous and systematically correct?

- (A) 3-methylbutane
- (B) 2,2,2-trimethylbutane
- (C) 2-methylbutane
- (D) 1-methylbutane
- (E) methylpentane

For problems 26 and 27, the following equations may be useful:

$$N = N_0 e^{-(\ln 2) \frac{t}{t_{1/2}}} \qquad \ln \left( \frac{N}{N_0} \right) = -(\ln 2) \frac{t}{t_{1/2}}$$

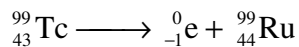
26. Technetium-99 has a half-life of  $2.12 \times 10^5$  years. If a sample originally contains 30.0 mg of  $^{99}\text{Tc}$ , how much will be left after one million years?

- (A) 25.9 mg
- (B) 789 mg
- (C) 1.14 mg
- (D) 21.6 mg
- (E) 34.7 mg

27. An artifact contains 12.5% of the amount of  $^{14}\text{C}$  present in living things. The half-life of  $^{14}\text{C}$  is 5,730 years. How old is the artifact?

- (A) 1,432 years
- (B) 2,865 years
- (C) 11,460 years
- (D) 17,190 years
- (E) 22,920 years

28. Technetium-99 is an unstable nuclide which is consumed by the following process:



What is this process an example of?

- (A) fission
- (B) fusion
- (C) positron emission
- (D) alpha decay
- (E) beta decay

29. Consider the melting point and boiling point data for a few substances:

Substance	Melting Point (°C)	Boiling Point (°C)
TiCl <sub>4</sub>	-24	136.4
SnCl <sub>4</sub>	-33	114

Which of the following statements are *false*?

- I.** It takes more energy to heat TiCl<sub>4</sub> from 90 to 91 °C than from 10 to 11 °C because the substance is closer to its boiling point.
- II.** TiCl<sub>4</sub> must have stronger intermolecular forces than SnCl<sub>4</sub> because it has higher melting and boiling points.
- III.** The strongest intermolecular interactions in both of these molecules are dipole-dipole forces.
- IV.** When they are solid, titanium tetrachloride and tin tetrachloride must be covalent solids because they have low melting points.

- (A) **II, III, and IV**
- (B) **III and IV**
- (C) **I only**
- (D) **IV only**
- (E) none of the above