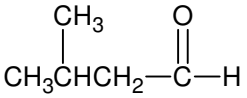
CHM 102
Final Exam

1. Provide unambiguous, systematic names for the following compounds:

a)



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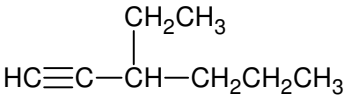

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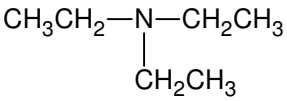

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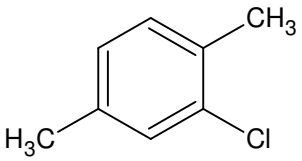

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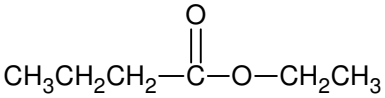


2. A 0.430 g sample of an unknown alkali metal hydroxide of formula MOH is dissolved in 25.00 mL of water and titrated with 42.0 mL of standard 0.100 M HCl.

a) Write a balanced chemical equation for this reaction, representing the unknown alkali metal with the symbol M.

b) How many moles of the alkali metal hydroxide are present in the sample?

c) What is the pH of the alkali metal hydroxide solution before titration?

d) What is the molar mass of the alkali metal hydroxide?

e) Which alkali metal is present in this compound?

3. Explain the following phenomena:

a) A properly named alkane cannot have a methyl group on carbon 1.

b) Carbohydrates are very soluble in water while lipids are insoluble in water.

c) The pH of a 1.0 M solution of nitrous acid (HNO_2) is higher than the pH of a 1.0 M solution of nitric acid (HNO_3)

4. One problem with sulfur chemistry is that many of the reaction products are volatile and foul-smelling, which can make even a well-ventilated lab unpleasant to work in. One way to partially circumvent this problem is to chemically convert these volatile sulfur compounds into nonvolatile aqueous salts. Bleach (sodium hypochlorite) is a convenient reagent to effect this transformation. Hydrogen sulfide reacts with hypochlorite to form sulfate and chloride:

$$H_2S(g) + ClO^-(aq) \rightarrow SO_4^{2-}(aq) + Cl^-(aq)$$

a) Assign oxidation states to all atoms in this reaction.

b) Which species is oxidized? Which species is reduced?

c) Using the method of half-reactions, balance this chemical equation.

d) Commercial bleach is 6.0% by mass NaClO. If a gas trap is charged with 1.00 kg of bleach, how many moles of hydrogen sulfide can it consume before the lab begins to smell offensive?

5. Using line-angle drawings or structural formulas, draw the following molecules:

a) 2,2-dimethyl-1-propanol

b) 2-methyl-1,3-butadiene

c) trifluoroethanoic acid

d) dimethyl ether

e) 4-methyl-2-butanone

6. Rank the following in terms of increasing melting point and explain your answers:

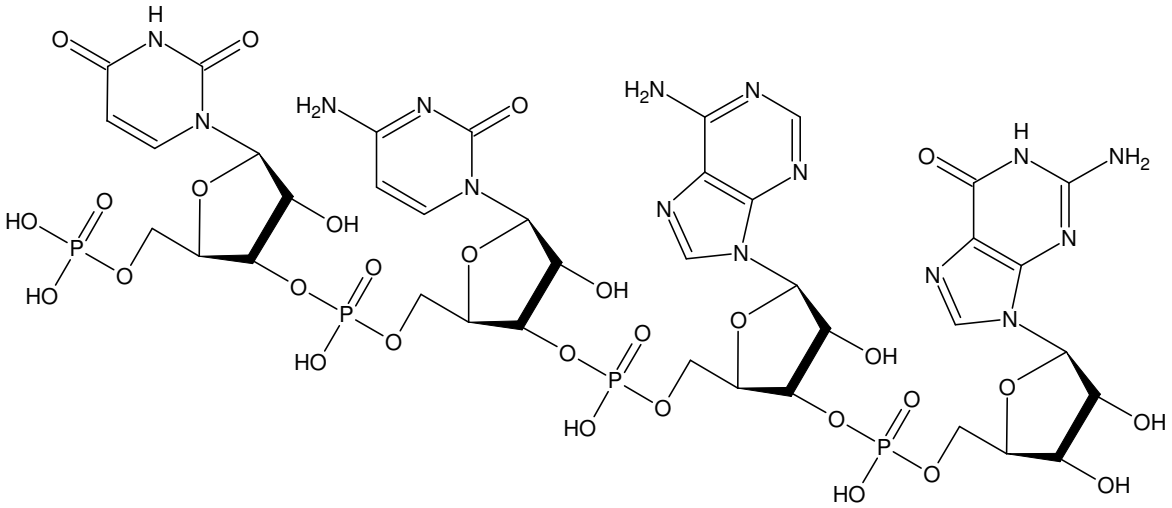
a) CH_3OH, CH_4, CH_3F

b) 1 m glucose, 1 m $CaCl_2$, distilled H_2O

7. Using a line-angle drawing or structural formula, draw three isomers with the formula $C_5H_{12}O$. Provide an unambiguous, systematic name for each isomer.

8. For each biochemical polymers listed below, determine whether it is a carbohydrate, lipid, protein, or nucleic acid, and how many monomers it contains.

a)



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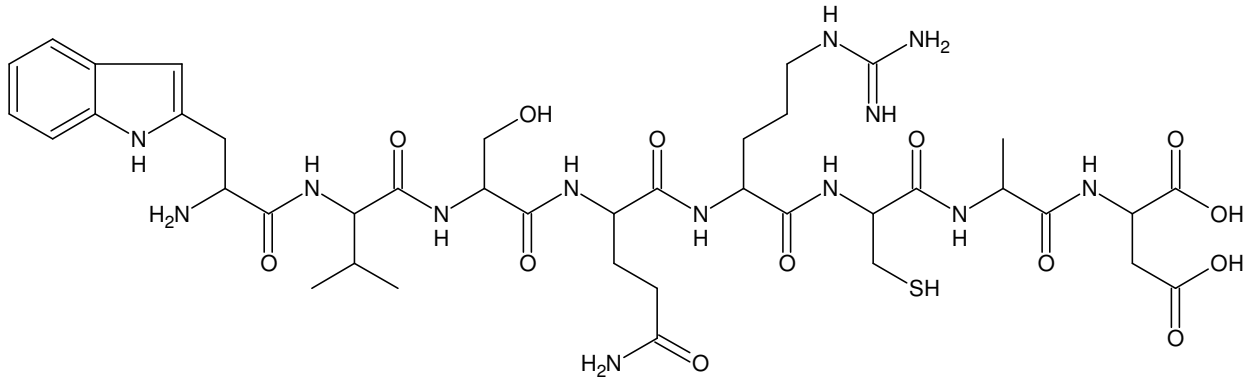

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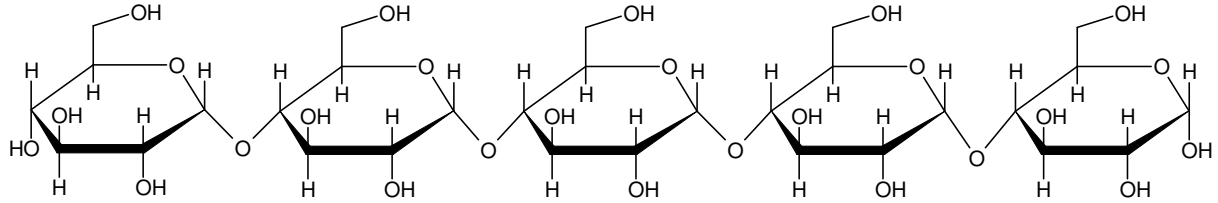


9. Methylamine (CH_3NH_2) is a weak base. Suppose you have a solution of 0.10 M methylamine.

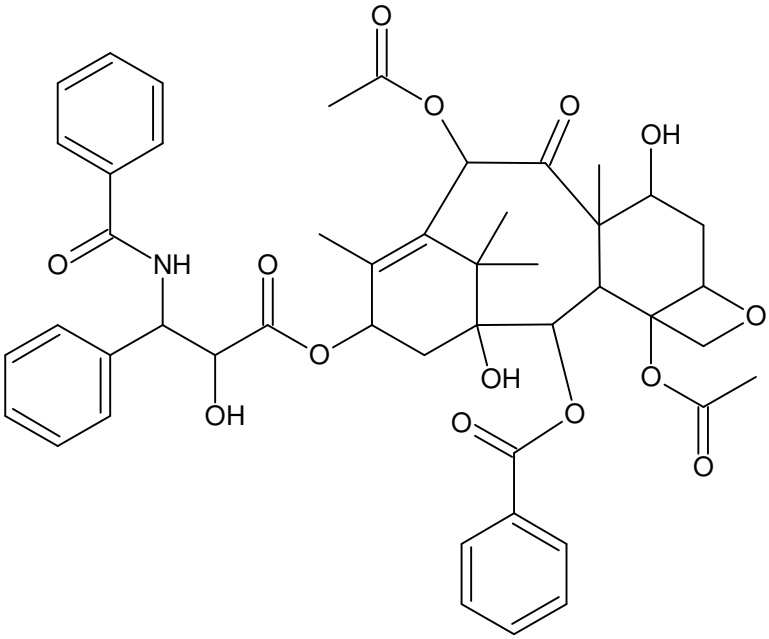
a) When dissolved in water, methylamine reacts with water in an acid-base reaction. Write a balanced chemical equation for this reaction. Under the equation, identify which species reacts as an acid, which species reacts as a base, which species is the conjugate acid, and which species is the conjugate base.

b) Write an equilibrium expression relating concentrations of the appropriate species to the equilibrium constant.

c) For this reaction, $K_{eq} = 4.17\times10^{-4}$. What does this tell you about the equilibrium position?

d) At equilibrium, the concentration of $[CH_3NH_3^+] = 0.0937$ M and $[CH_3NH_2] = 0.0063$ M. What is the concentration of hydroxide ions in this solution?

10. 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, halogen, alcohol, amine, ether, aldehyde, ketone, carboxylic acid, ester, amide). There are 14 functional groups in taxol.



Taxol

For the remaining questions, circle the letter that corresponds to the best answer.

11. Solution A has a pH of 3.00 and solution B has a pH of 5.00. Which of the following statements are *false*?

I. Solution A has ten times as many H_3O^+ ions as solution B.
II. Solution B has one hundred times as many OH^- ions as solution A.
III. Both solution A and solution B are basic.
IV. Solution B is more basic than solution A.
V. Solution A is more basic than solution B.

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

12. What is the reducing agent in the reaction below?

$$As_4O_6(s) + Cl_2(g) + H_2O(l) \rightarrow H_3AsO_4(aq) + HCl(aq)$$

(A) $As_4O_6(s)$
(B) $Cl_2(g)$
(C) $H_2O(l)$
(D) $H_3AsO_4(aq)$
(E) $HCl(aq)$

13. The radioactive decay of carbon-14 to nitrogen-14 occurs by the process of:

(A) positron emission
(B) α particle emission
(C) β particle emission
(D) γ ray emission
(E) spontaneous fission

14. Which of the following statements concerning acids and bases are *true*?

I. The dissociation equilibrium for a strong acid lies far to the right.
II. A strong acid always has a weak conjugate base.
III. A weak acid always has a strong conjugate base.
IV. As a substance becomes more acidic, its conjugate base becomes more basic.
V. Proton donating ability increases as the conjugate base of a substance gets weaker.

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

15. A 50.0 g sample of CH_3OH requires 54.9 kJ of energy to boil. What is the heat of vaporization?

(A) 1.10 kJ / mol
(B) 1.56 kJ / mol
(C) 32.0 kJ / mol
(D) 35.2 kJ / mol
(E) 85.6 kJ / mol

For questions, 16 and 17, refer to the activity series on the right:

The Activity Series

$Li(s) \rightarrow Li^{+}(aq) + e^{-}$
$K(s) \rightarrow K^{+}(aq) + e^{-}$
$Ca(s) \rightarrow Ca^{2+}(aq) + 2\ e^{-}$
$Na(s) \rightarrow Na^{+}(aq) + e^{-}$
$Mg(s) \rightarrow Mg^{2+}(aq) + 2\ e^{-}$
$Al(s) \rightarrow Al^{3+}(aq) + 3\ e^{-}$
$Mn(s) \rightarrow Mn^{2+}(aq) + 2\ e^{-}$
$Zn(s) \rightarrow Zn^{2+}(aq) + 2\ e^{-}$
$Cr(s) \rightarrow Cr^{3+}(aq) + 3\ e^{-}$
$Fe(s) \rightarrow Fe^{2+}(aq) + 2\ e^{-}$
$Ni(s) \rightarrow Ni^{2+}(aq) + 2\ e^{-}$
$Sn(s) \rightarrow Sn^{2+}(aq) + 2\ e^{-}$
$Pb(s) \rightarrow Pb^{2+}(aq) + 2\ e^{-}$
$\mathbf{H_2(g) \rightarrow 2\ H^{+}(aq) + 2\ e^{-}}$
$Cu(s) \rightarrow Cu^{2+}(aq) + 2\ e^{-}$
$Ag(s) \rightarrow Ag^{+}(aq) + e^{-}$
$Au(s) \rightarrow Au^{3+}(aq) + 3\ e^{-}$

16. Which of the following reactions are spontaneous?

I. $Mn^{2+}(aq) + Zn(s) \rightarrow Mn(s) + Zn^{2+}(aq)$
II. $3\ K\ (s) + Al^{3+}(aq) \rightarrow 3\ K^{+}(aq) + Al(s)$
III. $2\ Ag(s) + Fe^{2+}(aq) \rightarrow 2\ Ag^{+}(aq) + Fe(s)$
IV. $Ni^{2+}(aq) + Mg(s) \rightarrow Ni(s) + Mg^{2+}(aq)$
V. $2\ Au(s) + 3\ Ca^{2+}(aq) \rightarrow 2\ Au^{3+}(aq) + 3\ Ca(s)$

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

17. Which set of metals will dissolve in acid?

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

18. Concentrated nitric acid is 15.9 M. What volume of concentrated nitric acid must be diluted to 2.0 L to make a solution that is 1.0 M HNO_3?

(A) 8.0 mL
(B) 16 mL
(C) 31 mL
(D) 63 mL
(E) 126 mL

19. Which functional group does *not* contain a double bond?

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

For problems 20-23, consider the following disturbances to systems at equilibrium and predict the nature of the shift in the equilibrium position.

20. The endothermic reaction $N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$ is heated

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

21. The pH is lowered on $CH_3COOCH_3(aq) + OH^-(aq) \rightleftharpoons CH_3COO^-(aq) + CH_3OH(aq)$

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

22. $NH_4Cl(s)$ is removed from the system $NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s)$

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

23. The pressure is decreased on the system $2\ NO(g) \rightleftharpoons N_2(g) + O_2(g)$

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

24. The dihydrogen phosphate anion, $H_2PO_4^-$, has the ability to act as either an acid or a base. Therefore, $H_2PO_4^-$ is:

(A) isomeric
(B) saturated
(C) catalytic
(D) amphoteric
(E) colligative

25. Which of the following functional groups can engage in hydrogen bonding?

I. alkyne
II. alcohol
III. aldehyde
IV. amine
V. carboxylic acid

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

26. Addition of a neutron to thorium-233 can induce fission to form strontium-89, tellurium-141, and another particle(s):

$$^{1}_{0}n + ^{233}_{90}Th \rightarrow ^{89}_{38}Sr + ^{141}_{52}Te + ?$$

(A) $^{4}_{2}He$
(B) $3\ ^{1}_{0}n$
(C) $4\ ^{1}_{0}n$
(D) $4\ ^{1}_{1}p$
(E) $^{3}_{2}He$

27. 1.00 mol of the weak acid ethanoic acid is reacted with 0.50 mol of the strong base sodium hydroxide in aqueous solution. Which of the following describe the chemical properties of the resulting solution?

I. amphoteric
II. acidic
III. basic
IV. saturated
V. buffered

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

28. Soduim-24 is an unstable isotope with a half-life of 15.0 minutes. If a sample of $^{24}_{11}Na$ currently weighs 75 mg, how much of it was present an hour ago?

(A) 2400 mg
(B) 1200 mg
(C) 150 mg
(D) 9.38 mg
(E) 4.69 mg

29. If a given number of moles of NaCl changes the boiling point of 1 kg of water by 1.2 °C, then what is the boiling point of an identical number of moles of glucose in 1 kg of water?

(A) 97.6 °C
(B) 99.4 °C
(C) 100.6 °C
(D) 101.2 °C
(E) 102.4 °C

30. Which functional group contains nitrogen?

(A) aldehyde
(B) alcohol
(C) amide
(D) ether
(E) ester