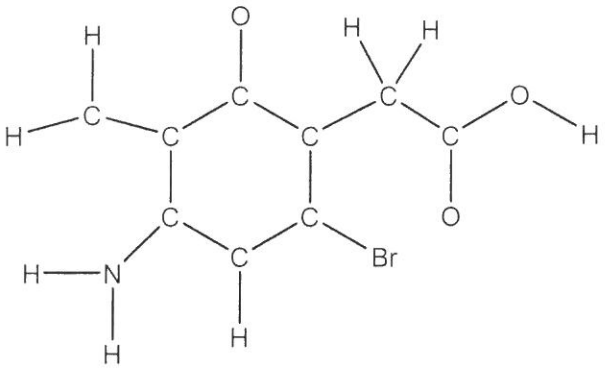
CHEMISTRY 102 Spring 2021
HOUR EXAM II

1. Complete a Lewis structure for the following organic compound:



How many C and N atoms in this organic compound are sp^2 hybridized?

a) 5 b) 6 c) 7

d) 8 e) 9 f) 10

2. Consider the following Lewis structure:

Which of the following statements is **false** concerning the bonding in this compound?

a) There are 2 pi (π) bonds in this molecule.

b) There are 4 sigma (σ) bonds in this molecule

c) In the H–C sigma (σ) bond, a 1s orbital from hydrogen overlaps with an sp hybrid orbital from carbon to form the sigma bond.

d) In the C–O sigma (σ) bond, an sp hybid orbital from carbon overlaps with an sp^3 hybrid orbital from oxygen to form the sigma bond.

e) In the triple bond, three unhybridized p atomic orbitals from each carbon overlap to form the three bonds between the two carbons.

3. Two valid resonance structures can be drawn for sulfur dioxide, SO_2. Which of the following five statements is **true** regarding the SO_2 molecule?

a) The pi (π) electrons in SO_2 are delocalized over the entire surface of the molecule.

b) The central sulfur atom is sp hybridized in one of the resonance structures and sp^2 hybridized in the other resonance structure.

c) There are 3 sigma (σ) bonds in SO_2.

d) All of the sigma bonds (σ) in SO_2 are formed from overlap of unhybridized p atomic orbitals.

e) In any one of the resonance structures, there are 2 pi (π) bonds.

4. A chemist finds a bottle of solid pellets labeled "strong base". She weighs out exactly 100.0 g of the strong base and reacts it with 5.00 *M* HCl. It takes 500.0 mL of the HCl to react completely with the strong base. Which of the following is the formula for the strong base?

a) LiOH b) NaOH c) KOH

d) RbOH e) $Ba(OH)_2$

5. In your Chem 103 laboratory, you find a mystery aqueous solution on the shelf. The solution may contain one or more of the following cations: Ni^{2+}, Ag^+, Ca^{2+}, Mn^{2+}. In order to determine the contents you add the following solutions: addition of excess aqueous hydrochloric acid causes a precipitate to form. The precipitate is removed, and excess aqueous potassium sulfate is added and another precipitate forms. The precipitate is removed, and aqueous sodium hydroxide is added to the solution; no precipitate forms upon addition of aqueous sodium hydroxide. Which ion/ions were present in the original mystery solution?

a) Ag^+ only b) Ni^{2+} and Ca^{2+} c) Ni^{2+} and Mn^{2+}

d) Ag^+ and Ca^{2+} e) Ni^{2+}, Ag^+, Ca^{2+}, and Mn^{2+} are all present.

6. Caffeine consists of carbon, hydrogen, oxygen, and nitrogen. When 0.1920 g of caffeine is burned in an excess of oxygen, 0.3482 g of carbon dioxide, 0.0891 g of water, and some nitrogen gas are formed. From the nitrogen gas produced, it was determined that caffeine is 28.84% nitrogen by mass. What is the mass percent of hydrogen in caffeine?

a) 5.19% H b) 23.20% H c) 1.27% H

d) 2.60% H e) 8.72% H

7. Caffeine consists of carbon, hydrogen, oxygen, and nitrogen. When 0.1920 g of caffeine is burned in an excess of oxygen, 0.3482 g of carbon dioxide, 0.0891 g of water, and some nitrogen gas are formed. From the nitrogen gas produced, it was determined that caffeine is 28.84% nitrogen by mass. What is the empirical formula for caffeine?

a) $C_4H_5N_2O$ b) $C_3H_3N_2O$ c) $C_4H_5N_2O_2$

d) $C_4H_{10}N_4O_4$ e) $C_2H_5N_2O_2$

8. A 2.402-g sample of urea contains 1.121 g N, 0.161 g H, 0.480 g C, and the rest oxygen. What is the empirical formula of urea?

a) NHCO b) $N_2H_3CO_2$ c) $N_4H_8C_2O$

d) N_2H_4CO e) $NH_2C_2O_2$

9. A mixture of 1.00 mol of $H_2(g)$ and 1.00 mol of $CH_4(g)$ is placed in a rigid (constant volume) container at some initial temperature. If the temperature of the container is increased, which of the following statements concerning this increase in temperature is **false**? Assume both gases behave ideally.

a) The partial pressure of $H_2(g)$ and the partial pressure of $CH_4(g)$ will both increase as the temperature is increased.

b) The $H_2(g)$ molecules will collide with the container walls more frequently as the temperature is increased.

c) The $CH_4(g)$ molecules will collide with the container walls more forcefully as the temperature is increased.

d) At the higher temperature, the $H_2(g)$ molecules will collide with the container walls more frequently as compared to the $CH_4(g)$ molecules.

e) At the higher temperature, the partial pressure of $H_2(g)$ will be greater than the partial pressure of $CH_4(g)$.

10. An actual yield of 3.00 g of aspirin (molar mass = 180.15 g/mol) are prepared in a laboratory according to the following equation:

$$2\ C_7H_6O_3(aq) + C_4H_6O_3(aq) \rightarrow 2\ C_9H_8O_4(s) + H_2O(l)$$

salicylic acid — acetic anhydride — aspirin

If the percent yield of the reaction is 70.0% and salicylic acid (molar mass = 138.12 g/mol) is in excess, what mass of acetic anhydride (molar mass = 102.09 g/mol) was used in the experiment?

a) 0.850 g b) 2.30 g c) 1.21 g d) 3.29 g e) 0.595 g

11. At 110.°C and 1.00 atm, 35.2 L of H_2 gas is reacted with 25.3 L of O_2 gas to produce H_2O gas. After the reaction, the H_2O gas is removed. What volume of H_2O gas at 110.°C and 1.00 atm can be produced?

a) 17.6 L b) 50.6 L c) 25.3 L d) 70.4 L e) 35.2 L

12. Consider the reaction of aluminum reacting with oxygen to form aluminum oxide. What mass of aluminum oxide can be produced when 20.0 g of Al is reacted with excess oxygen?

a) 37.8 g b) 19.8 g c) 8.2 g d) 75.6 g e) 10.0 g

13. In the titration of a 42.05 mL sample of commercial vinegar (d = 1.25 g/mL) with 1.20 *M* NaOH solution, it required 56.0 mL of the NaOH solution to react with all of the acetic acid in the vinegar. What is the mass percent of acetic acid in the vinegar? Acetic acid is a monoprotic acid and has a molar mass of 60.05 g/mol.

a) 9.60% b) 3.26% c) 12.0% d) 6.00% e) 7.68%

14. Which of the following compounds is expected to have a boiling point very close to NaF?

a) F_2O b) F_2 c) HF d) CF_4

e) None of these compounds will have a boiling point very close to NaF.

15. You are holding two balloons each filled with the same mass of gas. One balloon contains Ne gas and the other balloon contains Ar gas. Which of the following statements concerning these two balloons is **true**? Assume constant temperature.

a) The balloon filled with Ar gas and the balloon filled with Ne gas will have equal volumes.

b) The balloon filled with Ne gas will be about twice as large as the balloon filled with Ar gas.

c) The Ar balloon has an internal pressure which is about twice the pressure inside the Ne balloon.

d) The balloon filed with Ar gas will be about twice as large as the balloon filled with Ne gas.

e) The Ne balloon has an internal pressure which is about twice the pressure inside the Ar balloon.

16. A sample of gas containing 0.50 moles of CO_2 at 25°C exerts a pressure of 0.75 atm. More CO_2 gas is added to the container and the temperature is raised to 50.°C. The resulting pressure is 2.5 atm. How many moles of CO_2 were **added** to the container? Assume that the gas is ideal and that the container volume remains constant.

a) 1.0 moles b) 0.33 moles c) 1.5 moles

d) 0.83 moles e) 0.50 moles

17. Consider the following compounds (a-e), all of which are liquids at room temperature (20°C). Which compound would freeze first as the temperature is lowered from 20°C?

a) $CH_3CH_2CH_2CH_2-\overset{\overset{O}{\|}}{C}-H$ b) $CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-O-H$

c) $CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-CH_3$ d) $CH_3CH_2CH_2CH_2CH_2CH_3$

e) $CH_3CH_2CH_2CH_2CH_3$

18. Consider the following compounds (a-e), all of which are liquids at room temperature (20°C). Which compound has the **highest** vapor pressure at 20°C?

a) $CH_3CH_2CH_2CH_2-\overset{\overset{O}{\|}}{C}-H$

b) $CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-O-H$

c) $CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-CH_3$

d) $CH_3CH_2CH_2CH_2CH_2CH_3$

e) $CH_3CH_2CH_2CH_2CH_3$

19. How many of the following five compounds (I-V) are strong electrolytes when added to water?

I. $HC_2H_3O_2$ II. CH_3OH III. $(NH_4)_2CO_3$ IV. HNO_3 V. $FeCO_3$

a) 1 b) 2 c) 3 d) 4

e) 5 [All of these compounds (I-V) are strong electrolytes.]

20. Consider the following data concerning an unknown gas Z:

I. At 25°C, gas Z and $CO_2(g)$ have the same average kinetic energy.

II. At 25°C, gas Z has an effusion rate which is 1.25 times greater than the effusion rate of $N_2O(g)$.

III. Gas Z behaves more ideally at 1.00 atm and 25°C than at 100 atm and −75°C.

Which of the following could be gas Z?

a) F_2 b) Cl_2 c) CO_2 d) N_2 e) ClF

21. Consider the covalent compounds HCl, Cl_2, Br_2, HBr, and $CH_3CH_2CH_2CH_3$. How many of these 5 compounds is/are expected to have a boiling point greater than Ar?

a) 1 b) 2 c) 3 d) 4

e) 5 (HCl, Cl_2, Br_2, HBr, and $CH_3CH_2CH_2CH_3$ are all expected to have boiling points greater than Ar.)

22. Consider the van der Waals equation where *a* and *b* are some constants:

$$\left(P_{measured} + \frac{an^2}{V^2}\right)(V_{measured} - nb) = nRT$$

Which of the following gases would be expected to have the largest *a* value in the van der Waals equation?

a) Ar b) He c) HF d) N_2 e) CO

23. Consider the van der Waals equation where *a* and *b* are some constants:

$$\left(P_{measured} + \frac{an^2}{V^2}\right)(V_{measured} - nb) = nRT$$

Which of the following gases would be expected to have the smallest *b* value in the van der Waals equation?

a) Ar b) He c) HF d) N_2 e) CO

24. When magnesium nitrate reacts with sodium hydroxide, a precipitate forms. Which of the following is the **correct** net ionic equation for the precipitation reaction?

a) $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(s)$
b) $Mg^+(aq) + OH^-(aq) \rightarrow MgOH(s)$
c) $Na^{2+}(aq) + 2\ OH^-(aq) \rightarrow Na(OH)_2(s)$
d) $Mg^{2+}(aq) + 2\ OH^-(aq) \rightarrow Mg(OH)_2(s)$
e) $Mg^+(aq) + OH^{2-}(aq) \rightarrow Mg_2OH(s)$

25. If 50.0 mL of 0.200 *M* magnesium nitrate is added to 200.0 mL of 0.300 *M* sodium hydroxide, how many moles of precipitate will form assuming the reaction has a percent yield of 100%?

a) 0.0300 mol b) 0.0100 mol c) 0.0600 mol

d) 0.00500 mol e) 0.0200 mol

26. If 50.0 mL of 0.200 *M* magnesium nitrate is added to 200.0 mL of 0.300 *M* sodium hydroxide, what is the concentration of hydroxide ions after the reaction has gone to completion?

a) 0.300 *M* b) 0.240 *M* c) 0.160 *M*

d) 0.0800 *M* e) 0.0 *M*

27. A compound has the empirical formula CH_2O. If the density of the gaseous compound is 1.50 g/L at 125°C and 413 torr, what is the molecular formula of the compound?

a) CH_2O b) $C_2H_4O_2$ c) $C_3H_6O_3$ d) $C_4H_8O_4$ e) $C_5H_{10}O_5$

28. SO_2 is produced when substances containing sulfur (coal) are burned. SO_2 released into the atmosphere reacts to form sulfuric acid according to the equation:

$$2\ SO_2(g) + O_2(g) + 2\ H_2O(l) \rightarrow 2\ H_2SO_4(l)$$

What mass of H_2SO_4 (molar mass = 98.09 g/mol) can be produced if 64.0 g O_2 and 192 g SO_2 are combined with excess water?

a) 98.1 g b) 147 g c) 196 g d) 294 g e) 392 g

29. How many of the following five compounds (I-V) are soluble in water?

I. zinc chloride II. lead(II) nitrate III. lead(II) sulfate

IV. cobalt(III) sulfide V. magnesium chromate

a) 1 b) 2 c) 3 d) 4

e) 5 (All five of these compounds are soluble in water.)

30. An ionic compound MX_3 is prepared according to the following unbalanced chemical equation:

$$M + X_2 \rightarrow MX_3$$

A 0.105-g sample of X_2 contains 8.92×10^{20} molecules. The compound MX_3 consists of 54.47% X by mass. Which of the following is the formula for MX_3?

a) $AlCl_3$ b) CrH_3 c) TiF_3 d) YCl_3 e) $TlBr_3$