Problem Set 1: November 2022

Use the CCO Periodic Table and associated constants to answer these problems

1. An analytical chemist is preparing a solution of dilute HCl. They were trying to make a solution with a concentration of 1.50 mol L^{-1}, however they miscalculated. They ended up adding 50.0 mL of a 10.0 M stock solution to 150.0 mL of water. How much more water do they need to add to get to their desired 1.5 M solution?

    a. 444 mL
    b. 133 mL
    c. 333 mL
    d. 244 mL
    e. 150 mL

2. A chemist runs the reaction shown below. They initially start with 1.5 g of compound A and 1 g of compound B. After their reaction they isolate 1.19 g of a single product, giving them a yield of 64%. Which of the products did they isolate?


A	B		1	2	3
MW: 106.12 g/mole	44.05 g/mole		150.18 g/mole	132.16 g/mole	194.23 g/mole
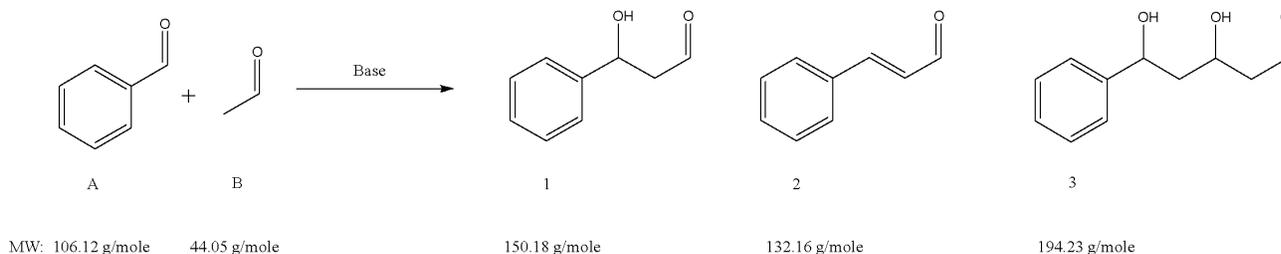
    a. Compound 1
    b. Compound 2
    c. Compound 3
    d. None of the above
    e. Not possible to calculate

3. How much energy (in kilojoules) would it take to heat 90.0 mL of water by 5.00 °C? The specific heat capacity of water is 4.18 J/g°C.

    a. 1.392 kJ
    b. 0.075 kJ
    c. 1.881 kJ
    d. 0.107 kJ
    e. 0.862 kJ

4. The ΔH_{vap} of water is 44.0 kJ mol^{-1}. How much energy (in joules) is needed for 110 mL of water to transition from the liquid state to the gaseous state?

    a. 269 x 10^3 J
    b. 244 x 10^3 J
    c. 275 x 10^3 J
    d. 302 x 10^3 J
    e. 484 x 10^3 J

5. Featured in the movie Erin Brockovich, the town of Hinkley California had its groundwater contaminated with hexavalent chromium in the 1950s. This was a result of poor chemical safety practices of a gas company. Tin(II) dichromate is a type of hexavalent chromium species. How many moles are in 3.70 g of pure tin(II) dichromate?

    a. 2.99 x 10^{-3} moles
    b. 1.05 x 10^{-2} moles
    c. 2.84 x 10^{-3} moles
    d. 1.11 x 10^{-2} moles
    e. 1.62 x 10^{-2} moles

6. Lithium metal is known to react with water to produce lithium hydroxide and hydrogen gas. How much space would the hydrogen gas formed occupy if 3.00 moles of lithium reacts with excess water? (Assume STP conditions)

    a. 67.2 L
    b. 11.2 L
    c. 44.8 L
    d. 22.4 L
    e. 33.6 L

Use the following structure to answer questions seven through nine below.
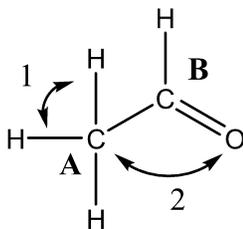
7. What is the approximate bond angle indicated by Arrow 1 shown above?

    a. 90°
    b. 109.5°
    c. 120°
    d. 180°
    e. 270°

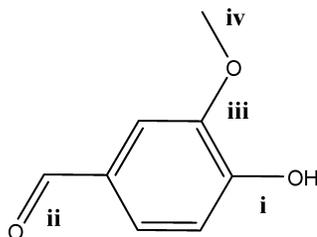8. What is the approximate bond angle indicated by Arrow 2 shown above?
    a. 90°
    b. 109.5°
    c. 120°
    d. 180°
    e. 270°

9. What is the hybridization of carbon atom B?

    a. sp
    b. sp^2
    c. sp^3
    d. Trigonal planar
    e. None of the above

Use the structure of Vanillin to answer question 10 and 11

10. Vanillin is a common flavoring agent used to give vanilla flavor to food. The structure for vanillin is shown below.

    Which C-O bond is the shortest?

    a. i
    b. ii
    c. iii
    d. iv
    e. They are all the same

11. How many π bonds are present in vanillin?

    a. 1
    b. 2
    c. 3
    d. 4
    e. 5

12. What is the conformation of a molecule with a central atom in group 15 period and period 3 which is covalently bonded to 5 fluorine atoms?

    a. Tetrahedral
    b. Octahedral
    c. T-shape
    d. Square pyramidal
    e. Trigonal bipyramidal

13. A chemist has four different compounds as listed below. Rank the compounds from highest to lowest boiling points.

$$i - CH_3OCH_3 \quad ii - CH_3CH_2COOH \quad iii - CH_3(CH_2)_8CH_3 \quad iv - CH_3OH$$

    a. i,ii,iii,iv
    b. i,iv,iii,ii
    c. iv,ii,i,iii
    d. iv,i,iii,ii
    e. iii,i,iv,ii

14. The Haber-Bosch Process is one of the most important discoveries to be made in chemistry. It is an artificial nitrogen fixation process which allows scientists to convert atmospheric nitrogen into ammonia; an important fertilizer.

$$N_2 + 3H_2 \rightarrow 2NH_3$$
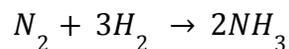
What mass of N_2 is required to produce 56.0 L of ammonia? (Assume STP conditions)
    a. 1.25 moles
    b. 1.00 moles
    c. 2.50 moles
    d. 5.00 moles
    e. 3.25 moles

15. How many electrons can have the quantum number n=4 and l=3?

   a. 0
   b. 2
   c. 6
   d. 10
   e. 14
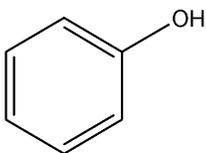
16. When n = 2 and l = 1, m_l could be equal to:

   a. +1
   b. 0
   c. -1
   d. A and B
   e. A, B, and C

17. Which of the following is the correct electron configuration for Xe?

   a. $[Kr]5s^2 5d^{10} 5p^6$
   b. $[Kr]4s^2 3d^{10} 4p^6$
   c. $[Kr]5s^2 4d^{10} 5p^6$
   d. $[Xe]5s^2 4d^{10} 5p^6$
   e. $[Xe]$
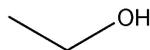
18. Which of the following compounds would be the most soluble in water?

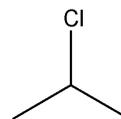Phenol   Cyclohexane   ethanol   2-chloropropane

   a. Phenol
   b. Cyclohexane
   c. Ethanol
   d. Acetone
   e. They are all equally soluble
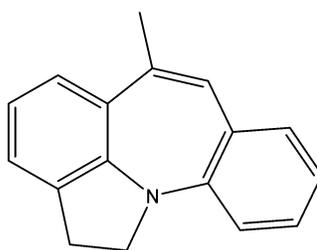
19. How many unpaired electrons are in Ni?

    a. 1
    b. 2
    c. 3
    d. 4
    e. 0

20. Rank the following atoms from highest first ionization energy to lowest:

                                   K , V , Se , Ba

    a. Ba, Se, V, K
    b. Se, V, K, Ba
    c. Ba, K, V, Se
    d. K, V, Se, Ba
    e. V, K, Se, Ba

21. How many hydrogen atoms are in the following molecule?

   a. 13
    b. 14
    c. 15
    d. 16
    e. 16

22. Which intermolecular forces would be present between ethanol and water?
    a. Hydrogen bonding
    b. Dipole-dipole interactions
    c. London forces
    d. Halogen bonding
    e. All A, B, and C

23. An experiment is performed where 250 light particles and 250 heavy particles are placed into a closed box at a temperature of 300 K and allowed to equilibrate. Which of the following statements are false?

    a. If the number of light and heavy particles are doubled, the pressure will double.
    b. The lighter particles have the same average speed than the large particles.
    c. If the volume of the box is doubled the pressure will half.
    d. Increasing the temperature will increase the average speed of the particles.
    e. The 250 light particles exert the same pressure on the box as the 250 heavy particles.

24. Silicon is a metalloid that has a high natural abundance. It is a key component of many things we are exposed to daily. A hypothetical mass spectrum of a sample of silicon containing 100 atoms is shown below. What is the average atomic mass of silicon in the sample?
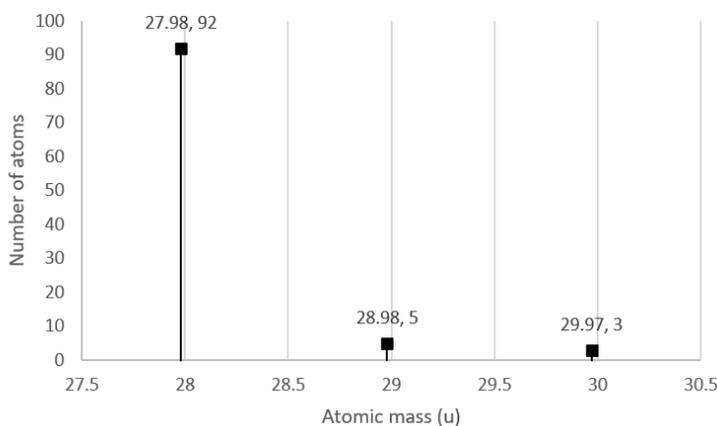
    a. 27.98 u
    b. 27.87 u
    c. 28.98 u
    d. 28.09 u
    e. 28.11 u

25. What is the energy of a mole of photons with a wavelength of 560 nm?

    a. 3.55×10^{-19} J mol^{-1}
    b. 3.55×10^{-26} J mol^{-1}
    c. 213 kJ mol^{-1}
    d. 3.55×10^{-22} J mol^{-1}
    e. 168 kJ mol^{-1}