Chemistry Lab Test

Palo Alto High School
50 minutes

Name: _____
Grade: _____

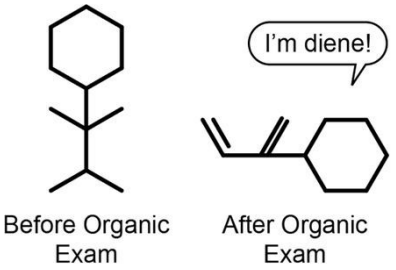
Score: _____/200

Chemistry Lab Captains Tryout 2019-2020

Answer concisely. Questions are not necessarily in increasing order of difficulty.
Have fun!

Warm Up Questions:

1. Chemistry is the study of matter and how they interact with other matter in their unique ways. List 3 branches/fields of chemistry:



2. Being the foolish person that you are, you drop a graduated cylinder full of concentrated sulfuric acid. Yikes. Assuming that the sulfuric acid did not get all over you, what is the first thing you should do?

3. What are the 3 most common…
    a. Subatomic particles:
    b. Elements in Earth's crust:

Multiple Choice Questions

For each question, there is only one right choice. No guessing penalties. Note that guessing E is not recommended. MC Question 1 is not representative of the entire test.

1. NaCl is well known as table salt. What is the IUPAC name for this compound?
    a. Sodium chloride
    b. Natrium carbon iodide
    c. Nacl (pronounced NAH-kul)
    d. Sodium chlorine
2. BrO_3^- is perhaps a less known compound. What is the common name for this compound?
    a. Brooo
    b. Bro minus
    c. Bromate
    d. Bromine trioxide

3. What is the IUPAC name for water (excluding the name “water”)?
    a. Dihydrogen oxygenide
    b. Mickey mouse molecule
    c. Hydroxic acid
    d. Dihydridooxygen
4. How many millimeters are there in 2.45 meters?
    a. 245 millimeters
    b. 2450 millimeters
    c. 24500 millimeters
    d. 245000 millimeters
5. How many angstroms are there in 4 picometers?
    a. 0.04 angstroms
    b. 4 angstroms
    c. 400 angstroms
    d. 40000 angstroms
6. Which ion is most likely to form a precipitate (undissolved solid)?
    a. NO_3^-
    b. NH_4^+
    c. Na^+
    d. CO_3^{2-}
7. The pH of a solution is 2. This solution is:
    a. Acidic
    b. Basic
    c. Neutral
    d. None of the above
8. Which compound is a diprotic acid?
    a. HNO_3
    b. H_2SO_4
    c. HCl
    d. HI
9. Which solution will have a pH less than 7?
    a. Ammonium chloride
    b. Sodium hydroxide
    c. Calcium hydroxide
    d. Sodium acetate
10. Which of the following is a strong base?
    a. $CH_3CO_2^-$
    b. HCl
    c. C_6H_5OH
    d. $Ca(OH)_2$
11. What is true about a strong acid?
    a. The acid can corrode any metal
    b. The solution generates excessive heat in contact with water
    c. The compound is virtually fully dissociated
    d. It can react with water to form hydrogen gas

12. Which acid/base indicator has a pH range of 6-7?
    a. Phenolphthalein
    b. Bromothymol blue
    c. Methyl red
    d. Potassium dichromate
13. A basic solution at room temperature has a hydronium concentration [H_3O^+] that is:
    a. 10^{-7}M
    b. Greater than 10^{-7}M
    c. Less than 10^{-7}M
    d. None of the above
14. Adding which 1 mole of which compound to pure water will *increase* the boiling point the most?
    a. NH_4Cl
    b. $Mg(NO_3)_2$
    c. C_2H_5OH
    d. Na_3PO_4
15. Adding which 1 mole of which compound to pure water will *decrease* the boiling point the most?
    a. NH_4Cl
    b. $Mg(NO_3)_2$
    c. C_2H_5OH
    d. Na_3PO_4
16. Given that Ksp of compound A is twice as large as the Ksp of compound B, which of the following is true?
    a. Compound A is twice as soluble as compound B
    b. Compound B is twice as soluble as compound A
    c. Compound A will deposit more mass of precipitate than compound B
    d. None of the above
17. NO_2 and N_2O_4 are in equilibrium in a clear rigid container. Which of the following changes will make the container appear brown?
    a. Decreasing the temperature
    b. Decreasing the atmospheric pressure
    c. Putting the container in a warm water bath
    d. Cracking open the container with a hammer
18. Bismuth has a negative slope between the solid and liquid boundary on a phase diagram. Based on the given information, which of the statements is true?
    a. Solid bismuth is more dense than liquid bismuth
    b. Bismuth sublimes at room temperature
    c. Bismuth condenses at 271.4°C
    d. Bismuth expands when frozen
19. Tartaric acid is an important food additive. Which of the following is the correct representation of tartaric acid?
    a. HOOCCHOHCHOHCOOH
    b. Et-$(OH)_2(COOH)_2$
    c. $C_4H_6O_4$
    d. $H_2C_2O_4$

20. HCl in a beaker exhibits the following equilibrium: $HCl + H_2O \leftrightarrow H_3O^+ + Cl^-$. Which of the following yields more H_3O^+?
    a. Diluting the solution with 50 mL of water
    b. Increasing the temperature of the solution
    c. Applying pressure onto the solution
    d. Adding 50mL of sodium epoxide
21. Which of the following compounds can be used as a buffer?
    a. Sodium hydroxide and water
    b. Dichromate and chromic acid
    c. Bromic acid and Bromide
    d. Oxalic acid and oxalate
22. The end point is defined by:
    a. The number of moles of acid equals the number of moles of base
    b. One drop before the solution turns pink in a titration
    c. The number of moles of hydronium ions equals the number of moles of hydroxide ions
    d. The moment the color changes in a titration
23. Which is true about indicators?
    a. They are weak acids
    b. The conjugate acid of phenolphthalein absorbs light in the UV range
    c. Methyl blue is a universal indicator
    d. Litmus paper turns red when in contact with acid
24. Why does the second deprotonation always have a lower Ka than the first?
    a. The increased polarity strengthens the force holding onto the second proton
    b. The ionization energy increases after each subsequent deprotonation
    c. Deprotonating a conjugate base adds more charge to a charged compound
    d. Other than hydrogen sulfate, all conjugates of diprotic acids are weak acids
25. Based on the HSAB theory, which compound is predicted to have the lowest solubility?
    a. AgF
    b. CaF_2
    c. $LaCl_3$
    d. Li_2CO_3
26. HCl and HBr are both strong acids, but their relative strengths can be determined by what principle?
    a. Bond dissociation energies
    b. Leveling effect
    c. Electronegativities
    d. Electropositivities

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27. Which of the following decreases the rate of a chemical reaction?
    a. Grinding up the reactant into a fine powder
    b. Increasing the temperature
    c. Increasing the concentration of the solutions used in the reaction
    d. Removing the catalyst in the reaction

28. Which is a correct value for the ideal gas constant?
    a. 0.0821 L•atm•$mol^{-1}K^{-1}$
    b. 8.31 L•J•mol^{-1}
    c. 22.4 J•mol^{-1}•K^{-1}
    d. 6.02 C•K•mol^{-1}
29. A high specific heat capacity for an object means:
    a. It is a conductor because it transmits heat well
    b. It is a semiconductor because it mildly transmits heat
    c. It has similar chemical reactivity as water
    d. It requires a lot of energy to increase the temperature of the substance
30. In the reaction $^{16}_{7}\mathrm{N} \rightarrow {}^{0}_{-1}e + {}^{16}_{8}\mathrm{O}$, nitrogen undergoes:
    a. Alpha decay
    b. Beta decay
    c. Positron emission
    d. Electron capture
31. Which is true of the anode in a galvanic cell?
    a. Reduction occurs
    b. The platinum increases in size due to deposited metal
    c. It can be turned into an electrolytic cell if enough voltage is supplied
    d. Zinc is commonly used as the anode in an alkaline battery
32. Which of the following quantum numbers is not possible?
    a. n = 2, l = 0, m_l = 0 m_s = ½
    b. n = 4, l = 4, m_l = 3 m_s = ½
    c. n = 3, l = 1, m_l = 1 m_s = -½
    d. n = 6, l = 4, m_l = -2 m_s = -½
33. Which of the following matches the compound with the correct electron pair geometry?
    a. Hydrogen iodide : Trigonal bipyramidal
    b. Antimony fluoride : Octahedral
    c. Imidazole: Trigonal planar
    d. Xenon tetroxide: Bicapped trigonal prismatic
34. Which is not true about a rotavap?
    a. It is used to evaporate solvents very efficiently
    b. It is fastened vertically like a distillation apparatus
    c. It usually uses a water bath to prevent freezing
    d. It requires the use of a keck clamp
35. This class of polymers has many properties, one being the ability to completely seal itself after being cut into pieces. What is the name of these polymers?
    a. Hydrogels
    b. Hyaluronic acid
    c. Elastomers
    d. Aerogels

Short Answer Questions

Please show all work for questions requiring calculations. Sig Figs will not be graded.

1. Boom! Fireworks are in the sky. What ions make fireworks appear red and green, respectively?

2. You're creating a sauce for your dumplings which include vinegar and sesame oil. You want them to mix but they stay as two distinct layers. Including "polarity" in your answer, explain why they don't mix well.

3. You are on an airplane and fly at an altitude of 35000 feet. You pull out the chip bag since you feel hungry, but you realize the bag is turgid and fully expanded. Use the variables in the ideal gas law to explain why this happened.

4. Calculate the pOH of a solution whose pH is 4 (at 25°C).

5. If the Ka of hydrofluoric acid is 6.6×10^{-4}, what is the pH of a 0.2M solution of hydrofluoric acid?

6. If the pH of a 0.6M base is 9, what is the percent protonation?

7. If you add 40mL of water to 180mL of 0.75M HBr, what is the resulting concentration of the solution?

8. If you add 250mL of 0.4M HNO_3 to 250mL of 1.0M NH_3 ($K_b = 1.8\times10^{-5}$), what is the resulting pH of the solution?

9. The solubility product of magnesium hydroxide is $1.8x10^{-11}$. Calculate the molar solubility of the magnesium ion a) in a pure solution. b) in a solution with 0.50M NaOH. c) in a solution with 0.50M $Ca(OH)_2$.

10. If you have 50mL of 1.0M acetic acid (CH_3COOH), what volume of 1.0M NaOH do you need to reach the a) equivalence point? b) half equivalence point?

11. Draw the Bohr diagram of fluorine. Draw the Lewis structure of fluorine.

12. When light enters the eye, the bond in cis-retinal is broken to create trans-retinal. a) How do cis and trans differ in structure? Draw a simple diagram depicting the difference. b) Are cis or trans structures more stable? Why?

13. Estimate the pH of 0.7M carbonic acid, given that Ka1 = 4.3×10^{-7} and Ka2 = 5.6×10^{-11}.

14. Given the half equations, $Pb^{2+} + 2e^- \rightarrow Pb$ ($E^\circ = -0.13V$) and $PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$ ($E^\circ = -0.13V$), what the solubility product of $PbSO_4$ at 25°C?

15. What is the molar solubility of silver chloride in 0.50M sodium cyanide, given that Ksp = 1.6×10^{-10} for silver chloride and Kf = 5.6×10^{8} for the silver cyanide complex?

16. Balance these chemical reactions:

    a. ___ CH_4 + ___ O_2 → ___ CO_2 + ___ H_2O

    b. ___ $AgNO_3$ + ___ $MgCl_2$ → ___ AgCl + ___ $Mg(NO_3)_2$

    c. ___ H_2O_2 $\xrightarrow{MnO_2}$ ___ H_2O + ___ O_2

    d. ___ $LiNO_3$ $\xrightarrow{\Delta}$ ___ Li_2O + ___ N_2O_4 + ___ O_2

    e. ___ $CuFeS_2$ + ___ O_2 $\xrightarrow{\Delta}$ ___ CuS + ___ FeO + ___ SO_2

    f. ___ MnO_4^- + ___ H_2O_2 + ___ H^+ → ___ Mn^{2+} + ___ H_2O + ___ O_2

17. List the names of all the equilibrium constants below:

    a. Kc: _____
    b. Kp: _____
    c. Ka: _____
    d. Kb: _____
    e. Kw: _____
    f. Ksp: _____
    g. Kd: _____
    h. Kf: _____

18. Periodic Table trivia - Name the element:

1. Dmitri Mendeleev hypothesized the existence and chemical properties of “Eka-silicon” using his periodic table.
2. This element has the atomic number of 100.
3. This element is obtained from pyrites (but it’s not iron or sulfur) or as a by-product from metal refining. A mercury alloy containing 8% of this element makes a low temperature thermometer.
4. Jöns Jacob Berzelius discovered silicon (Si) in addition to this element, commonly used in solar panels or printers as a photovoltaic. Its hexagonal crystalline form is gray and its monoclinic form is red.

1. _____
2. _____
3. _____
4. _____

* Extra fun fact: In 1794, John Gadolin discovered yttrium (Y) in the mineral called gadolinite in Ytterby, Sweden. In 1878, Jean Charles Galissard de Marignac subsequently discovered ytterbium (Yb) also in gadolinite and gadolinium (Gd) two years later in samarskite.

Beyond AP Chemistry level

For each question, there is only one right choice. No guessing penalties. Once again, guessing E is not recommended.

1. Based on the Crystal Field Theory, which functional group in the spectrochemical series will yield the highest spin complex?
    a. NH_3
    b. Cl^-
    c. $\underline{N}O_2$
    d. CN^-

2. When trying to convert 2-butyne to 2-butene, a poisoned catalyst is required. Which is not true about the reaction?
    a. Lindlar's catalyst is commonly used as a poisoned catalyst
    b. The reaction is always a syn-addition
    c. Pressurizing the reaction vessel will drive the reaction to form n-butane
    d. Poisoned catalysts are used in hydrogenation reactions

3. Which element forms cage-like cluster structures, can concatenate through coordinate covalent bonds, is used to make glass, and is combined with nitrogen to form an sp^2 hybridized compound that is used as an abrasive?
    a. Aluminum (Al)
    b. Boron (B)
    c. Sodium (Na)
    d. Sulfur (S)

4. .Which is not true about an NMR (nuclear magnetic resonance) spectrum?
    a. The chemical shift of D_2O is 0 in a C-13 NMR spectrum
    b. NMRs can detect characteristic absorbances of certain compounds
    c. NMRs use fourier transforms to process the data
    d. An MRI scan is an application of NMR

5. Adding lithium to aqueous ammonia can create a "solvated electron." This is known to create:
    a. A light spark in the reaction vessel
    b. A deep blue color
    c. A sustained stream of hydrogen gas
    d. A silver mirror coating onto the reaction vessel