MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

Unit II Minitest

31 Questions **30 Minutes**

This minitest is designed to assess your mastery of the content in Chapters 6 through 10 of this volume. The questions have been designed to simulate actual MCAT questions in terms of format and degree of difficulty. They are based on the content categories associated with the Foundational Concept that is the theme of this unit. They are also designed to test the scientific inquiry and reasoning skills that the test makers have identified as essential for success in medical school.

In this test, most of the questions are based on short passages that typically describe a laboratory experiment, a research study, or some similar process. There are also some questions that are not based on passages.

Use this test to measure your readiness for the actual MCAT. Try to answer all of the questions within the specified time limit. If you run out of time, you will know that you need to work on improving your pacing.

Complete answer explanations are provided at the end of the minitest. Pay particular attention to the answers for questions you got wrong or skipped. If necessary, go back and review the corresponding chapters or text sections in this unit.

Now turn the page and begin the Unit II Minitest.

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

Directions: *Choose the best answer to each of the following questions. Questions 1–5 are based on the following passage.*

Passage I

Fritz Haber (1868–1934) was a German chemist who designed a method for making ammonia from nitrogen and hydrogen. This was to Germany's advantage during World War I. The Haber process is an industrial method for making ammonia, NH_3. This process takes N_2 and H_2 gases and combines them at high temperatures (425 °C) and high pressures (200 atm) to force the triple-bonded nitrogen gas to react according to the reversible reaction:

$$N_2 + 3H_2 \leftrightarrow 2NH_3 + \text{heat}$$

The higher the pressure, the better the rate of reaction will be. A catalyst is also used in the reaction. Once made, ammonia can be used as a fertilizer, household cleaner, precursor to munitions, and smelling salts.

1. The K_{eq} for the reverse reaction is written as:
   A. $[NH_3]^2/[N_2][H_2]^3$
   B. $[N_2][H_2]^3/[NH_3]^2$
   C. $[NH_3]^2/[N_2] + [H_2]^3$
   D. $[N_2][H_2]/[NH_3]$
2. Which of the following scenarios shifts the reaction to the left?
   A. Not cooling the ammonia once it is formed
   B. Reacting the nitrogen and hydrogen at a higher pressure
   C. Adding more nitrogen gas and hydrogen gas to the reaction
   D. Using a catalyst
3. Addition of a catalyst will change:
   A. the heat of reaction
   B. the potential energy of the reactants
   C. the potential energy of the activated complex
   D. the point of equilibrium
4. The most probable point in the reaction that serves as the rate-determining step is:
   A. the cooling of the ammonia from a gas to a liquid
   B. the breaking of the bond between the hydrogen atoms
   C. nitrogen and hydrogen atoms reacting to form ammonia
   D. the breaking of the bond between the nitrogen atoms

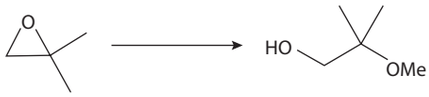
MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

5. The value of K_{eq} for this reaction can change with temperature. Given the temperatures of 300 °C, 400 °C, 500 °C, and 600 °C, which of the following is MOST likely the K_{eq} value when the reaction takes place at 600 °C?
   A. 4.3×10^{-3}
   B. 1.6×10^{-4}
   C. 1.5×10^{-5}
   D. 2.3×10^{-6}

Questions 6 and 7 are not based on a passage.

6. Which of the following BEST demonstrates the Lewis definition of an acid–base reaction?
   A. $HCl + NaOH \rightarrow NaCl + H_2O$
   B. $HCl + NH_3 \rightarrow NH_4^+ + Cl^-$
   C. $BF_3 + NH_3 \rightarrow F_3BNH_3$
   D. $CaO + SiO_2 \rightarrow CaSiO_3$

7. Which of the following are the BEST conditions for carrying out the following transformation shown?

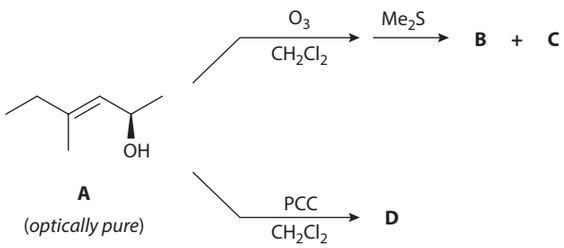


   A. sodium methoxide in methanol
   B. methyl iodide in methanol
   C. *p*-toluenesulfonic acid in methanol
   D. sodium iodide in methanol

Questions 8–11 are based on the following passage.

Passage II

When Compound A (shown) is treated with ozone followed by dimethylsulfide, two new products (B and C) are formed, both of which contain carbonyl groups. On the other hand, treatment of Compound A with pyridinium chlorochromate (PCC) results in a single new product (D).



MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

8. What is the best IUPAC name for Compound A?
   A. (2*R*, 3*Z*)-4-methylhex-3-en-2-ol
   B. (2*R*, 3*E*)-4-methylhex-3-en-2-ol
   C. (2*S*, 3*Z*)-4-methylhex-3-en-2-ol
   D. (2*S*, 3*E*)-4-methylhex-3-en-2-ol

9. The identities of ozonolysis products B and C are BEST described as:
   A. propanal and 2-hydroxypropanal
   B. propanal and 4-hydroxybutanone
   C. 2-butanone and 2-hydroxypropanal
   D. 2-butanone and 4-hydroxybutanone

10. In comparing the physical properties of starting material A and oxidation product D,
   A. the starting material (A) has a lower boiling point and the lower R_f value.
   B. the starting material (A) has a lower boiling point and the higher R_f value.
   C. the starting material (A) has a higher boiling point and the lower R_f value.
   D. the starting material (A) has a higher boiling point and the higher R_f value.

11. The most reasonable pK_a for the starting material (A) is:
   A. −7
   B. 7
   C. 17
   D. 27

Questions 12–16 are not based on a passage.

12. The final result of ATP production after anaerobic respiration is:
   A. the same as the amount of ATP made in aerobic respiration.
   B. equal to the amount of ATP made in glycolysis.
   C. low relative to the amount of ATP made in aerobic respiration.
   D. high relative to the amount of ATP made in aerobic respiration.

13. The drug DNP destroys the H^+ gradient that forms in the electron transport chain. The MOST likely consequence would be:
   A. the cells are forced to perform fermentation.
   B. ATP production increases.
   C. glycolysis stops.
   D. oxygen consumption increases.

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

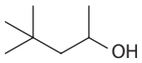
14. Which set of conditions shown here will NOT favor an S_N2 reaction?
    A. a strong nucleotide
    B. a leaving group on a primary carbon atom
    C. a lower temperature
    D. a solvent of a higher polarity
15. The approximate pK_a value of an organic compound is 50. This organic compound is MOST likely:
    A. an alcohol
    B. a carboxylic acid
    C. a terminal alkyne
    D. an alkane
16. The carbon dioxide exhaled by animals is produced in:
    A. glycolysis
    B. lactate fermentation
    C. Krebs cycle
    D. electron transport chain

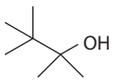
Questions 17–20 are based on the following passage.

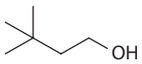
Passage III

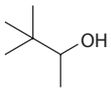
Reductive amination of Compound A with dimethylamine in the presence of sodium cyanoborohydride at pH 5.5 results in the formation of *N*, *N*,2,2-tetramethylpropan-1-amine.

On the other hand, Compound A reacts with methylmagnesium bromide to give another product (Compound B), which contains a hydroxyl group.

17. Which of the following is the most reasonable structure for Compound B?
    A. 

    B. 

    C. 

    D. 

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

18. Sodium cyanoborohydride is used instead of lithium aluminum hydride (LAH) for the reductive amination because:
    - **A.** sodium cyanoborohydride is a stronger source of hydride than LAH.
    - **B.** sodium cyanoborohydride is a milder source of hydride than LAH.
    - **C.** sodium cyanoborohydride is more sterically hindered than LAH.
    - **D.** sodium cyanoborohydride is less sterically hindered than LAH.
19. The BEST synthesis of methylmagnesium bromide (MeMgBr) is through:
    - **A.** the treatment of methane with magnesium metal and sodium bromide.
    - **B.** the treatment of methane with magnesium bromide.
    - **C.** the treatment of bromomethane with magnesium metal.
    - **D.** the treatment of methylmagnesium with bromine.
20. The functional group present in Compound A is BEST described as a(n):
    - **A.** ketone
    - **B.** ester
    - **C.** alcohol
    - **D.** aldehyde

Questions 21–25 are based on the following passage.

Passage IV

Human tooth enamel is composed of the mineral hydroxyapatite, which has the formula $Ca_5(PO_4)_3OH$. It is insoluble in water, but due to its basicity, it is soluble in acid solution.

Plaque forms on teeth due to a combination of carbohydrates and proteins, called mucin, which produces a film that builds up if not removed by thorough cleaning of the teeth and gums. Plaque traps food particles, which can be fermented by bacteria and produce lactic acid. Saliva does contain buffering agents that can neutralize acid in the mouth, but saliva cannot penetrate solid plaque. Lactic acid levels can drop to as low as pH 4.5 inside the plaque. As the plaque becomes more acidic, hydroxyapatite is converted to calcium hydrogen phosphate, which dissolves in water. The equation is as follows:

$$Ca_5(PO_4)_3OH\ (s) + 4\ H_3O^+\ (aq) \rightarrow 3\ CaHPO_4\ (aq) + 2\ Ca^{+2}\ (aq) + 5\ H_2O \quad (1)$$

When the hydroxyapatite reacts, cavities can form. The addition of fluoride to municipal water supplies and to toothpaste has lowered the incidence of cavities in children in the United States. Many children also have fluoride treatments as part of their routine dental care.

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

Fluoride has the ability to replace the hydroxide ion in hydroxyapatite, forming a compound called fluoroapatite. Fluoroapatite not only has a smaller K_{sp} value than hydroxyapatite, it is less basic as well. Thus it is far less soluble in acid solution. The reaction of fluoride with hydroxyapatite is as follows:

$$Ca_5(PO_4)_3OH\ (s) + F^-\ (aq) \rightleftharpoons Ca_5(PO_4)_3F\ (s) + OH^-\ (aq)$$

The K_{sp} of hydroxyapatite is 7×10^{-37}. The K_{sp} of fluoroapatite is 1×10^{-60}.

21. The dissolution of hydroxyapatite in water is BEST represented by:
    A. $Ca_5(PO_4)_3OH\ (s) \rightleftharpoons 5\ Ca\ (aq) + 3\ PO_4\ (aq) + OH\ (aq)$
    B. $Ca_5(PO_4)_3OH\ (s) \rightleftharpoons Ca_5\ (aq) + (PO_4)_3\ (aq) + OH\ (aq)$
    C. $Ca_5(PO_4)_3OH\ (s) \rightleftharpoons Ca_5\ (PO_4)_3^{+1}\ (aq) + OH^-\ (aq)$
    D. $Ca_5(PO_4)_3OH\ (s) \rightleftharpoons 5\ Ca^{+2}\ (aq) + 3\ PO_4^{-3}\ (aq) + OH^-\ (aq)$

22. Why does the equilibrium of the reaction of hydroxyapatite with fluoride lie to the right?
    A. Fluoride is a weaker base than hydroxide.
    B. Hydroxide can be removed as it is formed by buffers in saliva.
    C. Fluoroapatite is less soluble than the reactant.
    D. The product solidifies onto the surface of the tooth.

23. A larger K_{sp} value means that:
    A. reactants predominate.
    B. products predominate.
    C. there is a lower concentration of ions.
    D. the solid is less soluble.

24. What is the effect on the solubility of hydroxyapatite if calcium ions are added to a saturated solution?
    A. The equilibrium will shift to the right.
    B. The equilibrium will shift to the left.
    C. There will be no effect.
    D. More hydroxyapatite will ionize.

25. The solubility of hydroxyapatite, x, can be found from:
    A. $K_{sp} = x^3$
    B. $K_{sp} = x^5$
    C. $K_{sp} = x^7$
    D. $K_{sp} = x^9$

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

Questions 26 is not associated with a passage.

26. Which of the following represents the proper Lewis structure for fluoride?

A. 

B. 

C. 

D. 

Questions 27–31 are based on the following passage.

Passage V

In a laboratory exercise, a student was given a variety of unknown compounds, all household chemicals, to identify. The student was told that the unknowns included NaCl, $NaHCO_3$ (baking soda), sugar ($C_{12}H_{22}O_{11}$), $MgSO_4$ (Epsom salts), $Na_2S_2O_3$ (a photographic fixer), cornstarch, and chalk ($CaCO_3$). The student was asked to identify six of the unknowns using a series of qualitative tests.

The student was also given the following information:

- Starch and one of the other compounds are insoluble in water. The rest are soluble in water.
- Chalk produces a gas when treated with acid.
- Starch turns blue when treated with iodine.
- $MgSO_4$ produces a milky precipitate when treated with aqueous ammonia.
- $NaHCO_3$ turns pink when treated with phenolphthalein.
- $Na_2S_2O_3$ decolorizes iodine solution.
- NaCl conducts electricity in solution.
- Sugar does not conduct electricity in solution.

The student prepared a flow chart that would aid in doing the experiments in a systematic manner and allow efficient identification of the unknowns.

Experiment

The six unknowns were tested for solubility and conductivity. Each unknown was reacted with the following four reagents: acid, phenolpthalein, ammonia, and iodine. The results of these tests are in the table below. A Y indicates a positive test or reaction, and an N indicates a negative test or no reaction.

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

Results

Unknown	Solub	Conductivity	Acid	Phenolphthalein	NH_3	I_2
A	Y	Y	N	N	N	N
B	N	N	Y	N	N	N
C	Y	Y	N	N	Y	N
D	N	N	N	N	N	Y_{BLUE}
E	Y	Y	Y	Y	N	N
F	Y	Y	N	N	N	$Y_{COLORLESS}$

From these results the student was able to identify all six unknowns.

27. Which of the following unknowns is also insoluble in water?
    A. $NaHCO_3$
    B. $Na_2S_2O_3$
    C. $CaCO_3$
    D. $MgSO_4$
28. Unknown C was determined to be:
    A. $NaHCO_3$
    B. $Na_2S_2O_3$
    C. $CaCO_3$
    D. $MgSO_4$
29. Unknown A was determined to be:
    A. $CaCO_3$
    B. NaCl
    C. $Na_2S_2O_3$
    D. starch
30. The reaction of chalk, $CaCO_3$, produces a gas when treated with acid. This gas is:
    A. oxygen, O_2
    B. carbonic acid, H_2CO_3
    C. carbon dioxide, CO_2
    D. hydrochloric acid, HCl
31. The milky precipitate that is formed when $MgSO_4$ reacts with aqueous ammonia solution is most likely:
    A. $Mg(OH)_2$
    B. $(NH_4)_2SO_4$
    C. $Mg(NH_3)_2$
    D. NH_4OH

This is the end of the Unit II Minitest.

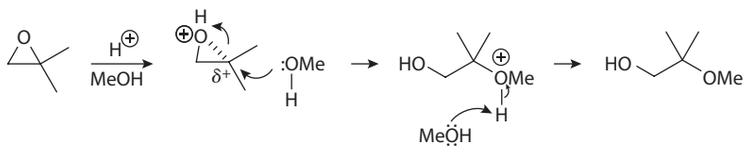
MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

Unit II Minitest Answers and Explanations

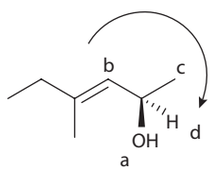
1. **The correct answer is B.** When writing the K_{eq} for a reaction, you need to remember "products over reactants, coefficients become powers." Looking at the reaction in reverse, ammonia is the reactant and the nitrogen and hydrogen gases are the products. This is best demonstrated by choice B.
2. **The correct answer is A.** Because the reaction is exothermic, the addition or presence of heat (a product) will cause more products to be present. More products present will mean that the reaction will shift to produce more reactants. This is why it is vital to cool the ammonia once it is formed. The next two choices favor the reaction to proceed to the right. Choice D, the catalyst, has no effect on the point of equilibrium. However, the catalyst will help equilibrium be achieved faster.
3. **The correct answer is C.** The addition of a catalyst will lower the activation energy by producing an alternative pathway for the reaction to proceed. This makes the potential energy of the activated complex lower. Because the potential energy of the reactants and products does not change, the heat of reaction will not change as well.
4. **The correct answer is D.** The rate-determining step is the slowest of the elementary steps of the reaction. The reaction has to overcome the triple-bonded nitrogen to form nitrogen atoms that need to react. This is why the 79 percent of the atmosphere which is nitrogen gas is considered inert (for the most part).
5. **The correct answer is D.** Because the reaction is exothermic, the increase in temperature will drive the equilibrium to the left. This causes more reactants to form. A greater concentration of reactants means a greater value in the denominator of the K_{eq} expression and a lower K_{eq} value.
6. **The correct answer is C.** This question touches on four different definitions of acids and bases. While they do not replace each other, they do enhance each other, depending upon the conditions. Choice A is the classic Arrhenius definition in which H^+ and OH^- neutralize to form water. Choice B shows a proton transfer and demonstrates the Brønsted–Lowry definition. The reaction in choice C shows the ammonia (base) donating a pair of electrons to boron trifluoride (acid), which is indicative of the Lewis definition of an acid–base reaction. The final reaction in choice D shows the less popular Lux–Flood definition in which an O^{2-} ion is transferred from the base (CaO) to the acid (SiO_2).

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

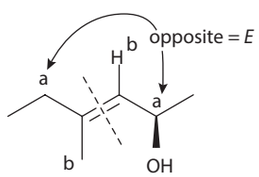
7. **The correct answer is C.** The product shown is the result of a nucleophilic ring opening of an epoxide. Methyl iodide can be discounted because it does not represent a competent nucleophile. Sodium iodide does provide a good nucleophile (iodide), but it would not provide the product shown. The choice then becomes one of base-catalyzed or acid-catalyzed ring opening in methanol. Here the regiochemistry is the deciding factor. Note that the methoxy group ends up at the more substituted position; yet methoxide (Condition A) would attack at the least hindered (less substituted) position. However, under acidic conditions, the protonated epoxide already starts to open, elongating the bond between the oxygen and the more substituted carbon (i.e., more able to sustain positive character). The lone pair on the methanol is then attracted to the developing positive charge at that site, leading to the product shown.



8. **The correct answer is B.** Starting with the chiral center, the priorities can be assigned as follows:



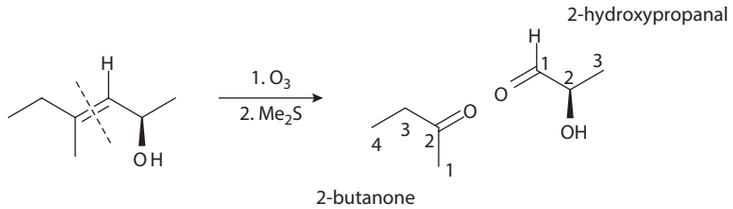
Because the lowest priority is directed away from the observer, and the progression a → b → c describes a clockwise motion, the chiral center is *R*. The double bond is specified using the same priority rules. Assigning priority to the substituents on either side of the double bond, you have:



Because the two substituents of the same priority are on opposite sides of the double bond, it is given the *E* (*entgegen*) designation.

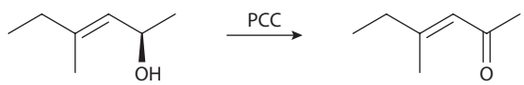
MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

9. **The correct answer is C.** Recall that ozonolysis is a type of oxidative cleavage that severs a double bond and, in the case of a reductive workup such as dimethyl sulfide, places a carbonyl at each terminus of the olefin:



Because the total carbon count is the same, choices A and D can be excluded (6 carbons and 8 carbons, respectively). The decision between choice B and choice C is governed by regiochemistry (the hydroxyl group remains on the 3-carbon fragment).

10. **The correct answer is C.** The product of the oxidation is the corresponding ketone, as follows:



The molecular weights of the two compounds are virtually identical; therefore, physical properties are governed primarily by differences in functional groups. Compared to ketones, alcohols can serve as both hydrogen bond donors and acceptors, and thus form more extensive H-bond networks, resulting in higher boiling points (e.g., consider the extraordinarily high boiling point of water). For the same reason, an alcohol tends to bind more tightly to the polar silica gel in chromatography, resulting in lower R_f values.

11. **The correct answer is C.** For the purposes of acidity, the starting material is best classified as a secondary alcohol. A suitable familiar model for such a substrate is 2-propanol (isopropanol), which has a pK_a of about 17.

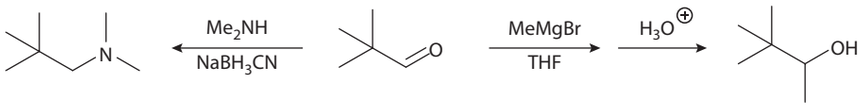
12. **The correct answer is C.** Aerobic respiration produces far more ATP than anaerobic respiration. The process of anaerobic respiration produces 2 ATP (both from glycolysis), whereas aerobic respiration produces about 36 ATP from glycolysis, Krebs cycle, and the electron transport chain. The most accurate answer would be choice C: anaerobic respiration produces far less ATP than aerobic respiration.

13. **The correct answer is A.** If the H^+ (proton) gradient were to be destroyed, the electron transport chain would be affected, as it is the only step of cellular respiration that relies on a concentration gradient. You must look for the choice that relates to how a cell performs cellular respiration without an electron transport chain. The only option is to move to anaerobic respiration, which requires fermentation, as indicated by choice A.

14. **The correct answer is D.** S_N2 reactions take place with stronger nucleophiles, leaving groups on primary carbon atoms and at lower temperatures. A polar solvent favors the formation of ions, a characteristic *not* found in S_N2 reactions.

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

15. **The correct answer is D.** Ethanol has a pK_a of about 16 and, as expected, acetic acid has a pK_a of about 4.8 as the lower pK_a value. Terminal alkynes can give up their terminal hydrogen atoms in a base so as to react and extend the carbon chain when reacted with the proper alkyl halide. A terminal alkyne has a pK_a value of about 25 for its terminal hydrogen atoms. Alkanes are not very acidic at all and have a very high pK_a value of about 50.
16. **The correct answer is C.** This question relies on direct recollection of the steps of aerobic respiration. During the Krebs cycle, CO_2 is released as citric acid, broken down, and rearranged. There is no release of CO_2 in any other steps of aerobic respiration.
17. **The correct answer is D.** The conditions leading to the formation of *N*,*N*,2,2-tetramethylpropan-1-amine represent reductive amination, which occurs between amines and carbonyl compounds in the presence of a reducing agent such as sodium cyanoborohydride. Since the amine component is given as dimethylamine, then consideration of the remaining carbon fragment leads to the conclusion that Compound A is the aldehyde. The conditions leading to Compound B are evocative of the Grignard reaction, which proceeds by nucleophilic addition to a carbonyl.

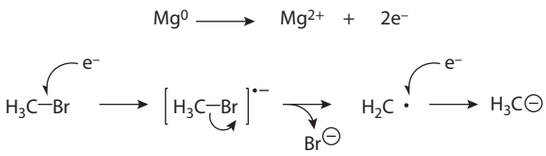


Compound A **Compound B**

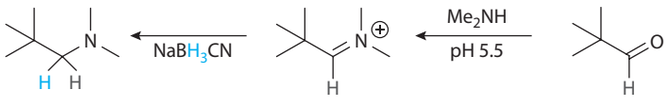
18. **The correct answer is B.** Sodium cyanoborohydride is a much milder source of hydride than LAH, which allows for its use under the acidic conditions necessary for iminium formation. If LAH were placed in an environment of pH 5.5, the following reaction would immediately (and violently) ensue:

$$H^- + H^+ \rightarrow H_2(g)$$

19. **The correct answer is C.** Grignard reagents are prepared by the reduction of haloalkanes with magnesium metal, following the mechanism shown here:



20. **The correct answer is D.** Examination of the amine product reveals a methylene group (i.e., 2 hydrogens) adjacent to the nitrogen. Only one of the hydrogens came from the hydride source (blue); the other (red) was already attached to the carbonyl carbon, meaning the starting material was an aldehyde.



MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

21. **The correct answer is D.** Choice D shows all correct charges and coefficients for the equation. Five moles of calcium ions contribute +10. Three moles of phosphate ions contribute −9. One mole of hydroxide ions contributes −1. Adding them together results in a net of zero, signifying that the overall charge of the products is equal to the charge of the reactant.
22. **The correct answer is A.** The direction will lie toward the species that is the stronger base. Because hydroxide is a stronger base than fluoride, the equilibrium will lie to the right.
23. **The correct answer is B.** A larger K_{sp} means that the substance is more soluble and that more ions will be produced. Because the ions are the products, a larger K_{sp} means that the products predominate.
24. **The correct answer is B.** A common ion lowers the solubility of the salt. An increase in calcium ion is an increase in the concentration of a product. The equilibrium will then shift to the left so as to consume this increase and make more reactant.
25. **The correct answer is D.** Choice D shows the correct Lewis structure for fluoride ion. Fluorine atom starts with seven valence electrons. Adding one more electron to complete the octet, produces an ion with a negative 1 charge.
26. **The correct answer is D.** A total of 9 ions are formed when hydroxyapatite dissolves. Because the coefficient of each ion becomes the power of the concentration, you have $[x]^5 \cdot [x]^3 \cdot [x]^1 = [x]^9$.
27. **The correct answer is C.** To determine the unknowns, you begin by summarizing the given information as follows:

Compound	Given information
NaCl	solutions are conductive
$NaHCO_3$	turns pink with phenolphthalein
Sugar	solutions are non-conductive
$MgSO_4$	produces a white precipitate with ammonia
$Na_2S_2O_3$	decolorizes iodine
Cornstarch	insoluble in water and turns blue with iodine
$CaCO_3$	produces a gas with acid
????	one unidentified compound is insoluble

You are given the information that starch and another compound are insoluble. The two insoluble compounds from the results table are B and D. Compound D can be identified as starch because it is the only substance that turns blue with iodine. To identify compound B you must try to find a distinguishing property. The only positive chemical test for compound B is the reaction with acid. Compound E also reacts positively with acid. Compound E can be identified as $NaHCO_3$ because it is the only substance that reacts with phenolphthalein. You are given the information that $CaCO_3$ reacts with acid, so it must be the insoluble compound. This problem could also be solved by recalling the basic solubility rules which include: All sodium salts are soluble (eliminating choices A and B). All sulfates are soluble with a few exceptions such as Pb^{2+}, Ba^{2+}, and Hg_2^{2+} (eliminating choice D). All carbonates with a few exceptions are insoluble (confirming choice C).

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2

28. **The correct answer is D.** The only positive chemical test for C was the reaction with ammonia. You are given the information that $MgSO_4$ produces a milky-white precipitate with ammonia.
29. **The correct answer is B.** Of the seven compounds about which information is given, five have at least one reaction with the chemical reagents: $NaHCO_3$ (phenolphthalein), $MgSO_4$ (ammonia), $Na_2S_2O_3$ (iodine), cornstarch (iodine), and $CaCO_3$ (acid). This leaves only NaCl and sugar. These two are distinguishable based on conductivity. NaCl solutions are conductive as is unknown A, but sugar solutions are non-conductive, so unknown A must be NaCl.
30. **The correct answer is C.** Ionic carbonates and hydrogen carbonates (also called bicarbonates) react with acids to form the unstable compound carbonic acid. Carbonic acid rapidly decomposes to carbon dioxide and water. The gas observed is carbon dioxide.

    The reaction for carbonates is:

    $$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow \text{“}H_2CO_3(aq)\text{”} \rightarrow H_2O(l) + CO_2(g)$$

    The reaction for hydrogen carbonates is:

    $$HCO_3^-(aq) + H^+(aq) \rightarrow \text{“}H_2CO_3(aq)\text{”} \rightarrow H_2O(l) + CO_2(g)$$

31. **The correct answer is A.** Ammonia is a base that produces hydroxide ions in water by abstracting a proton from a water molecule.

    $$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

    The hydroxide ions combine with magnesium ions to form the sparingly soluble compound magnesium hydroxide which appears as a white precipitate.

    $$Mg^{2+}(aq) + 2OH(aq) \rightarrow Mg(OH)_2(s)$$

MCAT-3200184 book November 13, 2015 15:31 MHID: 1-25-958837-8 ISBN: 1-25-958837-2