

Annotated Solution

2014 USNCO Local Exam

Authors: Ritvik Teegavarapu
Proofreaders and Editors: Junyu Yang and Dr. Qiang 'Steven' Chen

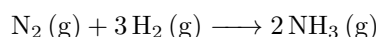
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1. This is a standard mass percentage problem, where the percentage of magnesium by mass can be found using:

$$\% \text{ Mg} = \frac{\text{mass Mg}}{\text{mass compound}}$$

This yields fractions of 17.70% (A), 11.13% (B), 17.09% (C), and 27.74%. Thus, $\text{Mg}_3(\text{PO}_4)_2$, or **D**, has the highest mass percentage. An inspection of the answer choices yields the same result. Both A and B have only 1 Mg and comparable molecular weights, making their mass percentages lower than C and D. Thus, these can be eliminated. Between C and D, D has more magnesium and less phosphorus.

2. Here is an equation for the reaction between N_2 and H_2 :



To determine the limiting reagent, we count the number of N_2 (5) and H_2 (12) molecules. Three molecules of H_2 are needed for every molecule of N_2 ; since we have 12 molecules of N_2 instead of 15, H_2 is the limiting reagent. Now, calculate the amount of ammonia formed:

$$12 \text{ molecules H}_2 \times \frac{2 \text{ molecules NH}_3}{3 \text{ molecules H}_2} = \boxed{8 \text{ molecules NH}_3}$$

This corresponds with **C**.

3. Using dimensional analysis and Avogadro's number to determine the number of atoms, we get **B**.

$$0.0450 \text{ g} \times \frac{1 \text{ mol C}_8\text{H}_8\text{O}_3}{152 \text{ g}} \times \frac{3 \text{ mol O}}{1 \text{ mol C}_3\text{H}_8\text{O}_3} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol O}} = \boxed{5.35 \times 10^{20} \text{ atoms}}$$

4. We know that the moles of the solute before dilution must equal the moles of solute after dilution. Let $M_1 = 0.550 \text{ M}$, $V_1 = 0.250 \text{ L}$, and $V_2 = 1.25 \text{ L}$.

$$\begin{aligned} M_1 V_1 &= M_2 V_2 \\ (0.550 \text{ M})(0.250 \text{ L}) &= M_2(1.25 \text{ L}) \\ M_2 &= 0.110 \text{ M Na}_2\text{SO}_4 \end{aligned}$$

However, reading the question, we want the molarity of the sodium ions. Thus, we can do dimensional analysis to calculate this.

$$\frac{0.110 \text{ mol Na}_2\text{SO}_4}{1 \text{ L}} \times \frac{2 \text{ mol Na}^+}{1 \text{ mol Na}_2\text{SO}_4} = \boxed{0.220 \text{ M}}$$

Thus, the correct answer is **C**.

5. Convert the numbers we're given into g/L, and then compare with the given solubility.

$$\frac{6.0 \text{ g}}{50. \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 120 \frac{\text{g}}{\text{L}}$$

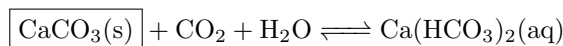
A saturated solution would have a concentration exactly equal to the solubility. The new solution is less saturated, so it is , or .

6. Strong electrolytes exist in solution as ions; weak electrolytes barely dissociate. Look through the answer choices for an insoluble salt or weak acid. , or , is a weak acid that barely dissociates. NaF (B) and KCl (D) are both highly soluble salts, and HCl (C) is a very strong acid.

7. When an element is in its elemental, or native forms, it exists unbound to any other elements. Halogens, for instance, are highly reactive, and we can eliminate A, B, and D. This leaves us , or . Nitrogen and oxygen exist as N₂ and O₂ in the air, and sulfur exists as S₈.

8. An oxidizing agent oxidizes another substance, and is reduced in the process. In these types of questions, look for the compound that where the central atom (S here) that is in its lowest oxidation state (i.e., can't be reduced any further). The compounds in the choices have oxidation states of -2, +4, +6, and +7. Sulfur needs two electrons to complete its octet, and so -2 is the lowest oxidation state that sulfur can have; , or , cannot be reduced further.

9. Rainwater, H₂O, picks up CO₂ as it falls down into the earth. Its reaction with CaCO₃ creates a slightly acidic aqueous solution:



Then, once the aqueous solution seeps into a cave with a lower pressure, the reverse reaction occurs and calcium carbonate deposits to form stalactites and stalagmites as predicted by the Le Chatelier's Principle. Thus, the answer is .

10. First, find the average, making sure to use proper significant figures:

$$\bar{\rho} = \frac{10.29 + 9.95 + 10.06 + 9.89 + 10.18}{5} = \frac{50.37}{5} = 10.07$$

The number after the plus/minus is the standard deviation. We don't actually need to find this. Just find the answer with the right number of significant figures in the average and standard deviation, which is , or .

11. Experiment 1 gets rid of all the water, leaving behind TS in mass 1. Experiment 2, using filtration, separates SS from the liquid. Evaporation of the liquid will leave just the dissolved solids, so DS = mass 2. By conservation of mass, SS = mass 1 - mass 2. Thus, the answer is .

12. I: Standard base will neutralize nitric acid, and the equivalence point can be found with an indicator. II: H⁺ will keep a +1 oxidation state, while N in NO₃⁻ is in its most oxidized state. No reaction will occur with a standard oxidizing agent. III: Precipitation with Ag⁺ will not work because AgNO₃ is soluble so there will be no precipitate. Thus, the answer is , or .

13. Tenets of kinetic molecular theory include the following: gas molecules have negligible volumes, gas particles are constantly and randomly moving, there are no attractive or repulsive forces between gas particles, and collisions between gas particles with each other or the wall are elastic (i.e., no kinetic energy is lost or gained.). A, B, and C are all consistent, leaving us .

14. We can use the combined gas law in order to answer this question.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

In this case, $P_2 = \frac{1}{2}P_1$, and $T_2 = \frac{1}{2}T_1$. Substituting, we get

$$\frac{P_1 V_1}{T_1} = \frac{\frac{P_1}{2} V_2}{\frac{T_1}{2}} = \frac{P_1 V_2}{T_1}$$

Simplifying, we get

$$V_1 = V_2$$

The volumes are equal, and the answer is **A**.

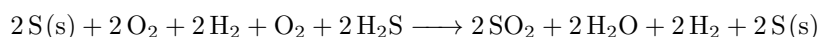
15. All molecules have dispersion forces (I). Because of the C–Cl bond dipoles, which do not cancel out due to the tetrahedral geometry, CH_2Cl_2 also has dipole-dipole forces. Thus, the answer is **C**.

16. Thanks to the strength of metallic bonding, most metals melt at high temperatures; B is out. Many types of solids, including metals and metalloids, are shiny and silver-white, or have three-dimensional order. The only characteristic unique to metals is being highly electrically conductive, or **D**.

17. The atoms of silicon are connected in a tetrahedral fashion with the carbon atoms. This describes a network covalent solid, or **D**.

18. Solutions with nonvolatile solutes have higher boiling points and lower melting points than pure substances. As such, Solution B will have a higher boiling point due to the presence of NaCl. The boiling point is defined as the temperature when the vapor pressure is equal to the atmospheric pressure; higher boiling points correlate with lower vapor pressures. This is represented in answer choice **C**.

19. First, manipulate the given chemical reactions to get the final reaction. We see that every reactant and product is in place except H_2S . So we will reverse the third reaction. Then, we will double all of the reactions in order to adjust the coefficients properly. Adding all of the new reactions we get



Now to calculate the ΔH , add the enthalpies of the component reactions.

$$\Delta H = 2\Delta H_1 + 2\Delta H_2 - 2\Delta H_3$$

$$\Delta H = 2(-296.8) + 2(-285.8) + 2(20.6) = -1124.0 \frac{\text{kJ}}{\text{mol}}$$

Thus, the correct answer is **D**.

20. $\Delta S^\circ < 0$ implies that entropy is decreasing throughout the reaction. Look for reactions where the products have less moles of gas than the reactants. Only **Option II**, or **B**, fits this specification.

21. 55.8 g Fe is 1 mol of Fe. Using the reaction given, we see that 1 mol Fe uses 0.75 mol O_2 . Thus, Fe is the limiting reactant, and O_2 is in excess. Now, we can do stoichiometry to determine the energy released noting that a negative enthalpy means a release of energy. Thus, the answer is **B**.

$$1 \text{ mol Fe} \times \frac{2 \text{ mol Fe}_2\text{O}_3}{4 \text{ mol Fe}} \times \frac{826 \text{ kJ released}}{\text{mol Fe}_2\text{O}_3} = 413 \text{ kJ}$$

22. The definition of specific heat is the amount of heat required to raise the temperature of one mass unit by 1°C . As the specific heat increases, the ΔT will decrease because more heat is required for the same temperature change. Metals with higher specific heats will cool less, so we can just order the given specific heats from least to greatest. This is **Pb < Zn < Fe**, or **B**.

23. The enthalpy of formation for elements in their standard state is 0, as there is no change in phase and no bonds are formed or broken. Thus, the correct answer is **A**.

24. As we add the water into the oven, it will turn into gas. The transition from liquid to gas is an increase in entropy, so $\Delta S > 0$. The oven must add heat to the water in order to boil it, $\Delta H > 0$. This temperature is above the boiling point of water, so the water will boil spontaneously, and $\Delta G < 0$. **C** is an accurate representation of the scenario given.

25. Using dimensional analysis to determine the rate of disappearance of $\text{CH}_3\text{CH}_2\text{OH}$, we obtain \boxed{C} .

$$\frac{1.24 \text{ mol K}_2\text{Cr}_2\text{O}_7}{\text{L} \times \text{min}} \times \frac{3 \text{ mol CH}_3\text{CH}_2\text{OH}}{2 \text{ mol K}_2\text{Cr}_2\text{O}_7} = \boxed{1.86 \frac{\text{M}}{\text{min}}}$$

26. $\boxed{\text{Decreasing size of graphite pieces}}$, or \boxed{A} , increases the surface area of the graphite, expediting the reaction. Decreasing temperature in B slows down the molecules and renders them less likely to collide favorably. Decreasing partial pressure, as in C or D, may decrease the rate of reaction (D) or has no change on the reaction rate (C).

27. The general rate law for a first order reaction can be written as such:

$$\text{Rate} = k[A]$$

We can see that the rate constant (B) is constant, depending only on temperature and activation energy (Arrhenius Equation) and that the rate law depends only on the reaction happening (C). However, since the reaction rate depends on the concentration of [A], which decreases as the reaction proceeds, the $\boxed{\text{reaction rate}}$, or \boxed{D} , decreases over time. From the integrated rate law, we can see that the half life (A) for a first order reaction is $\frac{\ln(2)}{k}$ and constant.

$$\ln([A]) = -kt + \ln([A]_0)$$

28. The general rate of the reaction is as follows.

$$R = k[A]^\alpha[B]^\beta$$

Going from Trial 1 to Trial 2, we can write the following equation.

$$\frac{6.5 \times 10^{-5}}{2.6 \times 10^{-4}} = \frac{(0.10)^\alpha(0.10)^\beta}{(0.20)^\alpha(0.10)^\beta}$$

This simplifies to

$$\frac{1}{4} = \left(\frac{1}{2}\right)^\alpha$$
$$\alpha = 2$$

Now going from Trial 2 to Trial 3, we get

$$\frac{2.6 \times 10^{-4}}{6.5 \times 10^{-5}} = \frac{(0.20)^\alpha(0.10)^\beta}{(0.10)^\alpha(0.20)^\beta}$$

This simplifies to

$$4 = 2^\alpha \times \left(\frac{1}{2}\right)^\beta$$

Substituting, we get

$$4 = 2^2 \times 2^{-\beta}$$
$$1 = 2^{-\beta}$$
$$\beta = 0$$

Thus, the correct rate law is $\boxed{k[A]^2}$, or \boxed{C} .

29. Let us start by writing the Arrhenius equation.

$$k = Ae^{\left(\frac{-E_a}{RT}\right)}$$

Where T is the temperature, E_a is the activation energy, R is the gas constant, and k is the rate constant. Taking \ln of both sides, we get

$$\ln k = \frac{-E_a}{RT} + \ln A$$

Expressing this in the form $y = mx + b$, with $x = \frac{1}{T}$, $y = \ln k$, and $b = \ln A$. Thus, the slope of the line can be expressed as

$$m = -\frac{E_a}{R}$$

Solving for E_a , we get

$$E_a = -R \times m = \boxed{-8.314 \times \text{slope}}$$

Thus, the answer is \boxed{B} .

30. A catalyst is a substance that speeds up a reaction by creating an $\boxed{\text{alternative path}}$ or \boxed{D} , with a lower energy of activation. It does not affect reaction thermodynamics (i.e., energy of the products or reactants, or equilibrium), and it is not consumed by the reaction. This eliminates A and C. As for B, catalysts interact with the reactants such that the original pathway is no longer possible.

31. Solids and liquids have constant concentrations and do not affect equilibrium constants. When calculating K , only count CO and O₂: \boxed{D} .

$$K = \frac{\boxed{[\text{CO}]^2}}{\boxed{[\text{O}_2]}}$$

32. I: C(s) is not in the equilibrium expression; adding some will not shift the equilibrium. II: Increasing temperature will increase the amount of heat in the system, and the reaction will try to consume this new heat. This is an exothermic reaction, which will shift left and decrease the amount of CO(g). III: The number of moles of gas of reactants and products are equal, so increasing pressure will have no effect. Thus, the answer is $\boxed{\text{none of these}}$, or \boxed{D} .

33. A negative ΔG corresponds with a K greater than 1, and vice versa. Looking at the following equation:

$$\Delta G = \Delta H - T\Delta S < 0$$

This reaction has a positive ΔH ; it requires heat, and this is not favorable. Positive ΔS is favorable (second law of thermodynamics). Only at high temperatures does the $T\Delta S$ outweigh the positive ΔH term. Thus, the correct answer is \boxed{B} .

34. With polyprotic acids, H⁺ removal becomes increasingly difficult with each subsequent ionization. The order K_a 's for any polyprotic acid must be

$$\boxed{K_1 > K_2 > K_3} > \dots > K_n$$

Thus, the correct answer is \boxed{C} .

35. Buffers consist of a weak acid or base, and its conjugate. A and D fail this requirement. An acidic buffer, specifically, consists of a weak acid and its conjugate base. C would be basic, because ammonia is a weak base with a $pK_b = 5$. Based on the Henderson-Hasselbalch equation, we can calculate that the pOH of NH₃-NH₄Cl ideal buffer equals to pK_b , thus, the pH = 14 - pOH = 5 This leaves us with $\boxed{\text{HF-NaF}}$, or \boxed{B} , where HF is a weak acid with a pK_a of 3, and NaF is its salt.

36. Calculate Q , the reaction quotient, and then compare it to the K_{sp} .

$$[\text{Pb}^{2+}] = \frac{0.040 \text{ M} \times 15.0 \text{ mL}}{15.0 \text{ mL} + 15.0 \text{ mL}} = 0.020 \text{ M}$$

$$[\text{Cl}^-] = \frac{0.040 \text{ M} \times 15.0 \text{ mL}}{15.0 \text{ mL} + 15.0 \text{ mL}} = 0.020 \text{ M}$$

Calculating Q , we get

$$Q = [\text{Pb}^{2+}][\text{Cl}^-]^2$$

$$Q = (0.020)(0.020)^2 = 8.0 \times 10^{-6}$$

If $Q < K_{sp}$, then the solution will be unsaturated and there will be no precipitate. However, if $Q > K_{sp}$, then the reaction will shift left until $Q = K$, forming precipitate. Comparing, we see $Q < K_{sp}$, so $\boxed{\text{no precipitate}}$ will form.

This leads us to \boxed{A} .

$$8.0 \times 10^{-6} < 1.7 \times 10^{-5}$$

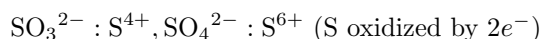
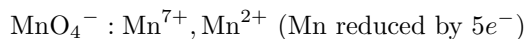
37. We can ignore the H_2O ; these are simply water molecules stuck to the rest of the molecule. We know the oxidation states of the other elements and ions, with $\text{K} = +1$, $\text{NH}_4 = +1$, $\text{As} = x$, and $\text{O} = -2$. This molecule is neutral, so the sum of all oxidation states must sum to zero.

$$+1 + 2(+1) + x + 4(-2) = 0$$

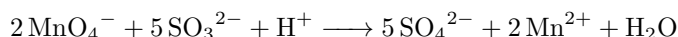
$$x = 8 - 3 = \boxed{+5}$$

Thus, the correct answer is \boxed{D} .

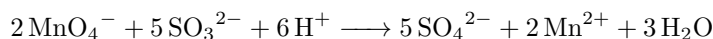
38. Redox reactions are best handled by first determining what's oxidized, and what's oxidized. (Keep in mind we need to balance not only the coefficients but also the charge.) First, balance all Mn-containing and S-containing molecules.



Find the LCM of the oxidation changes: 10. Multiply all the Mn by 2 and all the S by 5. So far we have



Now we have to balance the oxygens. There are 7 on the left but only 5 on the right. Thus we add 2 H_2O . Balancing hydrogen as well, the final reaction is



Thus, the coefficient of the H_2O is $\boxed{3}$, or \boxed{A} .

39. Reducing agents reduce, and are oxidized in the process. Of the given answer choices, H^+ (A) and Pd^{2+} (C) can't oxidized further with this set of reactions. A good reducing agent would be expected to have a low reduction potential; in other words, it's not easily reduced, and its oxidation is favorable. Looking at the chart, we see that $\boxed{\text{H}_2}$, or \boxed{B} is associated with the lowest E° .

40. Calculating E° for each of the answer choices yields the following. Remember that E° is an intrinsic property. You do not have to multiply it by coefficients.

$$\text{A: } E^\circ = E_{\text{Zn}}^\circ - E_{\text{Cr}}^\circ = -0.016 \text{ V}$$

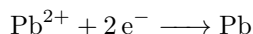
$$\text{B: } E^\circ = E_{\text{Cr}}^\circ - E_{\text{Zn}}^\circ = 0.016 \text{ V}$$

$$\text{C: } E^\circ = E_{\text{Zn}}^\circ - E_{\text{Fe}}^\circ = -0.351 \text{ V}$$

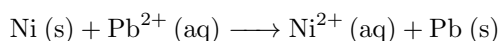
$$\text{D: } E^\circ = E_{\text{Zn}}^\circ - E_{\text{Fe}}^\circ = \boxed{0.351 \text{ V}}$$

Thus, \boxed{D} clearly offers the highest potential.

41. Start with writing the half reactions. Ni is oxidized (anode) and Pb is reduced (cathode):

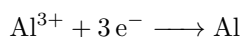


Adding the two half reactions, we get



To increase the voltage, K_{eq} must shift towards the products. $\boxed{\text{Diluting the Ni}^{2+}}$, or \boxed{A} , decreases the concentration of a product and pushes the reaction towards the right. A larger Ni electrode (B) increases surface area and thus the rate of reaction, but it does not affect equilibrium (Ni(s) is a solid and not in the equilibrium expression!). Adding NaCl to precipitate PbCl_2 consumes Pb^{2+} , a reactant, and pushes the reaction to the left. Adding more 1 M Pb^{2+} solution (D) increases the volume of solution, but does not affect the concentration of Pb^{2+} .

42. Three electrons are required to reduce Al_2O_3 to Al.



Faraday's law of electrolysis states that amount of substance produced at each electrode is directly proportional to the quantity of charge flowing through the cell and manifests as such:

$$m = \frac{M_W}{n} \times \frac{It}{F}$$

Solving for t , we get

$$t = \frac{mnF}{M_W I}$$

Plugging in $n = 3$ electrons, $F = 96500 \frac{\text{C}}{\text{mol}}$, $m = 250$ g, $I = 5.00$ A, and $M_W = 26.98 \frac{\text{g}}{\text{mol}}$, we get

$$t = \frac{250 \times 3 \times 96500}{26.98 \times 5.00} = 536500 \text{ s} = \boxed{149 \text{ hr}}$$

Thus, the correct answer is \boxed{B} .

43. We know that a s -subshell has 1 orbital, while a p -subshell has 3 orbitals. Every subshell is filled except $3p^4$. By Hund's rule, each orbital in the $3p$ subshell will have at least one electron (one will have two). Adding the number of s subshells and p subshells, we get \boxed{D} .

$$3(1) + 2(3) = \boxed{9}$$

44. Transitions to higher energy levels require the absorption of a photon. Transitions to lower energy levels release energy in the form of photons; choices B and D are automatically incorrect. From the energy of photons equation, longer photon wavelengths correspond with lower energies:

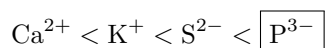
$$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E}$$

Between A and C, we want the transition with the lowest energy change. Gaps in energy levels drastically decrease as n gets larger. Thus, $\boxed{n = 5 \rightarrow 6}$, or \boxed{C} , would absorb photons of longer wavelengths than A.

45. A strict condition of quantum numbers is that $n > l$ as the maximum value of l is $n - 1$. Of the choices, $\boxed{n = l = 4}$, or \boxed{C} violates this rule.

46. Electronegativity (A) measures the tendency of an atom to attract electrons in a bond. $\boxed{\text{first electron affinity}}$, or \boxed{B} , is the energy released by a gaseous atom in its ground state upon accepting an electron and matches with the given reaction. First ionization energy (C) refers to the energy required to remove an electron from a neutrally charged atom in gas state. Lattice energy (D) is the energy required to separate a mole of an ionic solid into its gaseous cation and anion components.

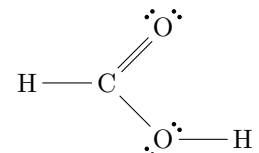
47. Two species are isoelectronic if they have the same number of electrons but different numbers of protons. Among the given species, the cations will be smaller. After removal of valence electrons, the highest energy electrons in K^+ and Ca^{2+} are in $n = 2$ and drastically less shielded from nuclear charge. Ca^{2+} is smaller than K^+ as Ca has a larger nuclear charge. Anions with higher negative charge will be larger, due to increased repulsion. The ordering of these species according to size is correctly given in \boxed{C} .



48. Metallic character increases from right to left, and top to bottom. All the given series increase in metallic character. Look for a series that starts with a clearly nonmetallic element and ends with a clearly metallic element. A and D consist of only metals, and C consists of only nonmetals. On the other hand, \boxed{B} starts with N, which is typical nonmetal, and ends with Sb, a metalloid.

49. Boron (A) has only three valence electrons. It cannot achieve an octet by simple sharing of electrons, and is prone to forming incomplete octets with six electrons. Chlorine (B) has access to $n = 3$ subshells so it can use its $3d$ subshell to hold more than eight electrons. Only [F], or [C], almost always follows the octet rule. Hydrogen (D) can only hold up to two electrons and observes the *duet* rule instead.

50. Bonding pairs can be found in bonds between atoms, and lone pairs are localized on individual atoms. Let's draw the Lewis structure.



From the Lewis structure, we see that there are [4] lone pairs (2 on each oxygen atom), and [5] bonding pairs. Thus, the correct answer is [D].

51. Lattice energy can be described using Coulomb's law:

$$E \propto \frac{Q_1 Q_2}{r}$$

With this type of questions, first find the salts with the most negative $Q_1 Q_2$ products. B and D both give a product of -4 , whereas A and C both give a product of -1 . Then look at ionic radii; smaller ionic radii lead to higher lattice energy. Between B and D, B contains ions from the second row of the periodic table, whereas D contains ions from the fourth row. Atomic and ionic radii increase from top to bottom, so BeO, or [B], has the highest lattice energy.

52. When calculating ΔH using bond energies:

$$\Delta H_{\text{reaction}} = \Sigma (\text{bonds in reactants}) - \Sigma (\text{bonds in products})$$

This is the opposite of calculating ΔH from heats of formation. Bonds in the reactants are broken and require energy; bonds in the products are formed and release energy.

$$\Delta H_{\text{reaction}} = 1 \text{ O-O} + 2 \text{ H-O} - (2 \text{ H-O} + \frac{1}{2} \text{ O=O}) = 1 \text{ O-O} - \frac{1}{2} \text{ O=O}$$

$$103 \text{ kJ/mol} = 1 \text{ O-O} - \frac{1}{2}(498)$$

$$\text{O-O} = \boxed{146 \text{ kJ/mol}}$$

Thus, the correct answer is [C].

53. The way to determine the number of π bonds in a molecule is by drawing the Lewis structures. Each double bond consists of one sigma bond and one pi bond, and each triple bond consists of one sigma bond and two pi bonds. C_2H_2 , CO_2 , and N_2 all have 2 π bonds, while [O₃], or [D], has 1.

54. Draw Lewis dot structures for each of the choices and compare their VSEPR shape. The only correct answer is [PCl₃], or [A]. B, or OF_2 has two lone pairs, which causes a bent shape. ClF_3 is not trigonal planar. It starts off as trigonal bipyramidal, and the presence of two lone pairs on the equatorial positions leaves us with a T-shaped molecule. With 6 fluorides, the hexagonal geometry for D is incorrect, but rather, it is octahedral.

55. Structural isomers are molecules that have the same molecular formula, but different connections. The only answer that resembles this definition is [A].

56. The presence of a $-\text{CHO}$ group tells us that this compound is an aldehyde, which is associated with the suffix -al. There are five carbons, so this is [pentanal], or [A].

57. The idea here is that bromine will add across a double or triple bond. B and D contain no double or triple bonds. Benzene (A), C_6H_6 , is very stable due to its aromaticity. Adding across one of its double bonds would disrupt its aromatic nature, and benzene resists reaction with Br_2 through addition. This leaves us with [1-hexene], or [C].

58. In this reaction, a carboxylic acid and alcohol are combined to form an ester. This is an esterification reaction, or B. In addition (A) reactions, atoms are added across double or triple bonds, reducing the degree of unsaturation (see: #57). In neutralization (C) reactions, an acid and base react with each other. Saponification (D) is the opposite of esterification; an ester breaks down into a carboxylic acid (in the form of carboxylate as base is added) and alcohol.

59. Some useful abbreviations to remember the most common elements in biological molecules: CHO for carbohydrates, CHON for proteins and amino acids, and CHONP for nucleic acids. Common amino acids do not contain phosphorous, or D.

60. Carbohydrates consist of simple sugars (e.g., glucose, fructose, galactose, sucrose, lactose) and also polysaccharides (starch, cellulose, chitin). Glycine, or B, is an amino acid. A rule of thumb: -ose denotes a simple sugar, -ine denotes amino acids (though other compounds may also have this suffix), and -ase denotes enzymes (a type of protein).