

Annotated Solution

2012 USNCO Local Exam

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1. We can use dimensional analysis and Avogadro's number to solve this problem.

$$4.0 \times 10^{-5} \text{ g} \times \frac{1 \text{ mol}}{26.98 \text{ g}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{\text{mol}} = \boxed{8.9 \times 10^{17} \text{ atoms}}$$

Thus, the answer is \boxed{A} .

2. Remember that 1 M is 1 mol/L. Also be careful, because the salt dissociates into multiple sulfate ions. Then we can do dimensional analysis.

$$100 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.0020 \text{ mol Fe}_2(\text{SO}_4)_3}{\text{L}} \times \frac{3 \text{ mol SO}_4^{2-}}{\text{mol Fe}_2(\text{SO}_4)_3} = \boxed{6.0 \times 10^{-4} \text{ mol SO}_4^{2-}}$$

Thus, the answer is \boxed{B} .

3. At higher temperatures, the volume of the water increases. The mass of the solutes stay the same. The mass of the water also stays the same. Molality is mol solute per kg water, so this does not change. Mole fraction is mol solute per combined moles of all the different types of solutes and solvents, so this does not change. Mass percentage is kg solute divided by kg solution, so this does not change. $\boxed{\text{Molarity}}$ is mol solute per liter solution. Since the volume of the water changes, but the moles of solute remains the same, the molarity will change accordingly. Thus, the answer is \boxed{A} .

4. We must use stoichiometry for this problem.

$$14.4 \text{ g C}_5\text{H}_{12} \times \frac{1 \text{ mol C}_5\text{H}_{12}}{72.15 \text{ g C}_5\text{H}_{12}} \times \frac{6 \text{ mol H}_2\text{O}}{\text{mol C}_5\text{H}_{12}} = \boxed{1.20 \text{ mol H}_2\text{O}}$$

This is \boxed{C} .

5. Notice that KHP is a monoprotic acid, while Ba(OH)₂ is a base with two hydroxide groups. Thus, we can predict that the KHP reacts with the Ba(OH)₂ in the reaction below.

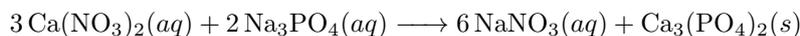


Now we can determine the molarity.

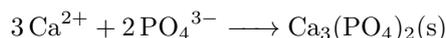
$$\frac{1.530 \text{ g KHP} \times \frac{1 \text{ mol KHP}}{204 \text{ g KHP}} \times \frac{1 \text{ mol Ba(OH)}_2}{2 \text{ mol KHP}}}{34.50 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}} = \boxed{0.109 \text{ M Ba(OH)}_2}$$

This is \boxed{C} .

6. First, let's write the reaction. Make sure to use solubility rules.



The net ionic equation is



From the net ionic equation, we see that no Na^+ or NO_3^- is used up, so we can eliminate A and D. Now let's find the initial amounts of reactants.

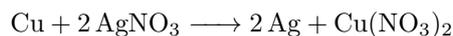
$$\text{Ca}^{2+} : 30.0 \text{ mL} \times 0.10 \text{ M Ca}(\text{NO}_3)_2 \times \frac{1 \text{ Ca}^{2+}}{\text{Ca}(\text{NO}_3)_2} = 3.0 \text{ mmol}$$

$$\text{PO}_4^{3-} : 15.0 \text{ mL} \times 0.20 \text{ M Na}_3\text{PO}_4 \times \frac{1 \text{ PO}_4^{3-}}{\text{Na}_3\text{PO}_4} = 3.0 \text{ mmol}$$

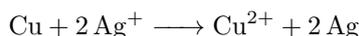
Both are initially present in the same amounts. However, from the net ionic equation, we see that more Ca^{2+} is used up than PO_4^{3-} . Thus, the answer is **C**.

7. HNO_3 can produce nitrogen oxides such as NO, NO_2 , and N_2O when reacting with metals even when it is dilute. Thus, the answer is **C**. As a note, diluted $\text{HCl}(\text{aq})$ and $\text{H}_2\text{SO}_4(\text{aq})$ produces hydrogen gas when reacting with reactive metals. Concentrated H_2SO_4 may produce SO_2 instead when reacting with metals.

8. We can eliminate A because logically, a piece of silver and a piece of copper will not react. We can eliminate D because both ions are positive, so they cannot form a compound. This leaves us with B and C. The correct answer is Ag^+ and Cu because in a well known demonstration, copper metal is replaced by silver dissolved in solution. You may predict the relative reactivities of Cu and Ag based on the periodicity as they are in the same group. The reaction is



The net ionic equation is



Thus, the answer is **B**.

9. Visible light ranges from about 380 nm to 700 nm. Looking at the wavelengths from the image, we see that the Balmer series, or **B**, contains lines in the visible region of the spectrum.

10. An aspirator is used to pump liquids. There are many more practical ways to measure height, such as metersticks. Thus, the answer is **A**.

11. We can eliminate B and D because these are chemical changes, so the bonds within the water molecules change. We can eliminate A because upon freezing water, more hydrogen bonds are formed between water molecules, but we do not know of their strength. The correct answer is **C** because when we boil water, the intermolecular forces (mainly hydrogen bonds) between water molecules are broken, but the bonds within water molecules remain intact. Thus, we know the bonds within water molecules are stronger. In another words, the boiling point of water is much lower compared to the temperature needed to decompose water through breaking the bonds within the water molecules.

12. This is a typical high school chemistry experiment used to learn the application of gas law. The formula for molar mass of a gas is

$$M = \frac{mRT}{PV}$$

Where m is the mass of the gas. (Note that the mass of the gas is the same as the mass of the liquid condensed in this experiment, which is much smaller than the initial mass of the liquid put in the flask) This equation can be derived from $PV = nRT$. Now let's make some rough approximations for the unknowns in this experiment.

$$m = \frac{MPV}{RT} \approx \frac{100 \text{ g mol}^{-1} \times 1 \text{ atm} \times 0.125 \text{ L}}{0.08206 \text{ atm L mol}^{-1} \text{ K}^{-1} \times 373 \text{ K}} = 0.4 \text{ g}$$

$$T \approx 373 \text{ K} (100 \text{ }^\circ\text{C})$$

the temperature of the gas approximates to that of the boiling water

$$P \approx 760 \text{ mm Hg} (1 \text{ atm})$$

$$V = 125 \text{ mL}$$

Now let's calculate the percent error for each component.

$$m : \frac{\pm 0.01 \text{ g}}{0.4 \text{ g}} \times 100\% = \pm 2.5\%$$

$$T : \frac{\pm 0.2 \text{ K}}{373 \text{ K}} \times 100\% = \pm 0.05\%$$

$$P : \frac{\pm 0.2 \text{ mm Hg}}{760 \text{ mm Hg}} \times 100\% = \pm 0.03\%$$

$$V : \frac{\pm 1.0 \text{ mL}}{125 \text{ mL}} \times 100\% = \pm 0.8\%$$

The mass, which is measured by the balance, has the highest percentage error. Thus, the answer is A. Note that the temperature used to calculate the error percent is in Kelvin as it is the unit used in the ideal gas law.

13. The intermolecular forces and kinetic energies are the two factors to determine the phase a substance at a certain condition. Kinetic energies make molecules move around, IMFs make molecules hold together. If the kinetic energies are much higher than the potential energies caused by the IMFs, the substance tends to be gaseous. If the potential energies are much higher, then it is a solid. If they are comparable, it tends to be a liquid. Thus, the answer is A.

14. We know from $PV = nRT$ that volume is proportional to temperature. Thus we can set up a proportion, being aware that we need to convert the temperatures to Kelvin.

$$4.2 \text{ L} \times \frac{(75 + 273) \text{ K}}{(25 + 273) \text{ K}} = 4.9 \text{ L}$$

$$\Delta V = 4.9 \text{ L} - 4.2 \text{ L} = \text{span style="border: 1px solid black; padding: 2px;">0.7 L}$$

This is A.

15. Past the critical point, liquid becomes indistinguishable from gas. Thus, liquid carbon dioxide cannot exist, and the only answer that fits this description is C.

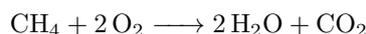
16. Silicon dioxide is well known for forming network covalent, or molecular solids. These include quartz and glass. Thus, the answer is D.

17. We must use unit cell rules for this question. There is 1 atom in the center. There are eight corner atoms, but each only counts for $\frac{1}{8}$ because it is shared between 8 unit cells. Thus, the answer is $1 + 8 \times \frac{1}{8} = \text{span style="border: 1px solid black; padding: 2px;">2}$, or B.

18. We can eliminate A because the hydrogen bonding in H_2O will lead to a much higher boiling point than the other substances. The weak dipole-dipole interaction in H_2S , H_2Se , and H_2Te is not the dominant factor here.

The other distinguishing factor is London dispersion force, as all the molecules other than water are nonpolar. Since London dispersion force increases with number of electrons, H_2S will have the least intermolecular forces. Therefore it will also have the lowest boiling point, so the answer is B.

19. First, let's write the combustion reaction.



Now we can do stoichiometry.

$$3.00 \text{ mol O}_2 \times \frac{1 \text{ mol CH}_4}{2 \text{ mol O}_2} \times \frac{-802 \text{ kJ}}{1.00 \text{ mol CH}_4} = \text{span style="border: 1px solid black; padding: 2px;">-1.20 \times 10^3 \text{ kJ}}$$

This is A.

20. We know the heat lost by the hot water equals the heat gained by the cold water. The change in energy of the system is zero.

$$\begin{aligned} -q_h &= q_c, \quad q_h + q_c = 0 \\ -(m_h)(C)(\Delta T_h) &= (m_c)(C)(\Delta T_c) \\ -(20.0)(4.184)(T_f - 80.0) &= (30.0)(4.184)(T_f - 20.0) \end{aligned}$$

Solving for T_f , we get $T_f = \boxed{44^\circ\text{C}}$. This is \boxed{B} .

21. For this question, we simply do products minus reactants based on Hess's Law.

$$\Delta H^\circ = 5(-167.1) + (-1284.4) - (-443.5) - 4(-285.8) = \boxed{-553.2 \text{ kJ} \cdot \text{mol}^{-1}}$$

Thus, the answer is \boxed{B} .

22. Answer choice A is the First Law of Thermodynamics. We can eliminate B because it contradicts the First Law of Thermodynamics. C is wrong because it contradicts D. \boxed{D} correctly states the Second Law of Thermodynamics, which is that $\boxed{\text{the entropy of the universe is increasing}}$.

23. We know $\Delta G = \Delta H - T\Delta S$, and we know that for a spontaneous reaction, $\Delta G < 0$. Therefore, we want $\boxed{\Delta H < 0}$ and $\boxed{\Delta S > 0}$ for a reaction to always be spontaneous. This is \boxed{D} .

24. For this question, we can use the equation $\Delta G^\circ = -RT \ln K$. We know $\boxed{\Delta G^\circ < 0}$ because the reaction is spontaneous at standard state, so we can eliminate B. We can eliminate A and C because the domain of a logarithm is only positive numbers, which implies that $\boxed{K > 0}$. Thus, the answer is \boxed{D} .

25. From the rate law, we see that more gas leads to an increased rate, so A works. Increasing temperature increases rate, so B works. Increasing the surface area of the solid allows more collisions between the gas and the solid, so D works. Increasing the $\boxed{\text{volume of the container}}$ will not work because it will space out the gas, bringing it farther away from the solid. Thus, the answer is \boxed{C} .

26. From the reaction, we see that for every two N_2O_5 consumed, one O_2 is produced. Thus we can calculate the rate of consumption of N_2O_5 and then use a ratio from the reaction.

$$\frac{0.080 \text{ mol N}_2\text{O}_5}{4.0 \text{ L} \times 0.20 \text{ s}} \times \frac{1 \text{ mol O}_2}{2 \text{ mol N}_2\text{O}_5} = \boxed{0.050 \text{ M s}^{-1}}$$

Thus, the answer is \boxed{B} .

27. A catalyst $\boxed{\text{decreases the activation energy}}$ of a reaction by providing an alternative pathway. From the Arrhenius equation, $k = Ae^{\frac{-E_a}{RT}}$, we see that the decrease in activation energy E_a increases the rate constant k . Thus, the answer is \boxed{C} .

28. The formula for half-life of a first order reaction is

$$t_{\frac{1}{2}} = \frac{\ln(2)}{k}$$

Thus we see that the half life remains the same. We also know that the rate of the reaction decreases, because the rate law is of the form $\text{rate} = k[\text{CH}_3\text{NC}]$, so as CH_3NC is used up, the rate will decrease proportionally. Thus, the answer is $\boxed{\text{Row B}}$, or \boxed{B} .

29. From Experiment One to Experiment Two, [A] is multiplied by 3 and [B] is multiplied by 2. Thus the rate will be $R \times 3^2 \times 2 = \boxed{18R}$, or \boxed{D} .

30. An intermediate is produced during the reaction and then consumed again. Looking at the answer choices, we see that the only one that its an intermediate is $\boxed{\text{RCOHOR}'^+}$, or \boxed{A} .

31. Equilibrium is defined as the point where the rate of the forward reaction is equal to the rate of the reverse reaction. This is not necessarily the point where the concentrations of the reactants and products are equal. Thus, the answer is I only, or A.

32. We can write the K_{sp} expression as

$$K_{sp} = [\text{Ba}^{2+}][\text{IO}_3^-]^2$$

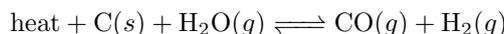
We know that for each dissolved $\text{Ba}(\text{IO}_3)_2$, there will be 1 Ba^{2+} and 2 IO_3^- produced. Thus, letting the solubility be x , we have

$$K_{sp} = (x)(2x)^2 = 4x^3$$

$$x = \sqrt[3]{\frac{K_{sp}}{4}} = \boxed{5.3 \times 10^{-4} \text{ M}}$$

This is C.

33. Because $\Delta H > 0$, the reaction is endothermic and requires a heat input. Thus we can write the reaction as



The equilibrium expression does not include solids or liquids.

$$K_{eq} = \frac{(P_{\text{CO}})(P_{\text{H}_2})}{(P_{\text{H}_2\text{O}})}$$

From the equilibrium expression, we see that the $\text{C}(s)$ has no effect on equilibrium, so I is incorrect. If we increase the volume of the container, pressure will decrease. By Le Chatelier's principle, the reaction will shift to increase pressure again. This will favor the forward reaction, because the increased number of moles of gas leads to higher pressure. Thus II is correct. If we increase the temperature, the forward endothermic reaction will be favored to decrease the temperature by Le Chatelier's principle. Thus III is correct. The answer is II and III, or C.

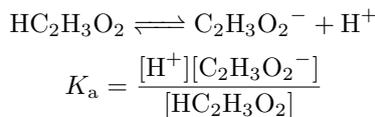
34. We know the number of moles of NaOH will equal the number of moles of weak acid. Thus we can say

$$(0.125 \text{ mol/L})(V) = (0.175 \text{ mol/L})(25.0 \text{ mL})$$

$$V = \boxed{35.0 \text{ mL}}$$

Thus, the answer is D. The amount of ionization has no effect on the equivalence point, as equivalence point is simply defined as the point where the moles of acid equals the moles of base. However, because this is a weak acid but a strong base, the pH will be greater than 7 at the equivalence point.

35. We can ignore the neutral Na^+ ion for this question. $\text{C}_2\text{H}_3\text{O}_2^-$ is the conjugate base of $\text{HC}_2\text{H}_3\text{O}_2$. The reaction is



Adding HCl will decrease the pH because it will add H^+ ions. Adding $\text{C}_2\text{H}_3\text{O}_2^-$ will increase the pH because it will cause a shift towards the reactants side of equilibrium, decreasing the concentration of H^+ . Now let's see what happens when we dilute the solution. First, we must find K_a .

$$K_a \approx \frac{(10^{-4.74})(0.10)}{(0.10)} = 10^{-4.74}$$

$$\frac{75 \text{ mL}}{125 \text{ mL}} = 0.6$$

$$Q_a = \frac{(0.6 \times 10^{-4.74})(0.6 \times 0.10)}{(0.6 \times 0.10)} = 1.09 \times 10^{-5} < K_a$$

Thus, we will have a right shift. Assuming that x is much less than 0.10×0.60 ,

$$K_a \approx \frac{(0.60 \times 10^{-4.74} + x)(0.60 \times 0.10)}{(0.60 \times 0.10)} = 0.60 \times 10^{-4.74} + x$$

$$x = 0.40 \times 10^{-4.74}$$

$$[\text{H}^+] = 0.60 \times 10^{-4.74} + x = 10^{-4.74} = K_a$$

Thus, the final H^+ concentration will be $10^{-4.74}$ M, and the final pH will still be 4.74. You can also easily get the same conclusion by applying the Henderson-Hasselbalch equation here as the ratio of the concentration of the acid and conjugate base doesn't change with dilution. Therefore, the answer is **I and II**, which is **C**.

36. Ammonia is a weak base and HCl is a strong acid. Thus we know that at the equivalence point, the pH will be less than 7. With this we can eliminate C and D. We also know that if there was no ammonia, the pH would be $-\log(0.10) = 1.0$. With the basic ammonia, the pH will be significantly more than this, so we can eliminate A. Thus, the best indicator is **methyl red**, and the answer is **B**.

37. In **ClO_2^-** , each oxygen has a -2 oxidation number, and the ion has a -1 charge overall. Thus we can set up an equation, with $\mathcal{O}(n)$ denoting the oxidation number of an element.

$$2(-2) + \mathcal{O}(\text{Cl}) = -1$$

$$\mathcal{O}(\text{Cl}) = +3$$

Thus, the answer is **A**. None of the other answer choices have an atom with an oxidation number of $+3$.

38. For a reaction to be spontaneous, it must have a positive cell potential. Thus we must flip one of these reactions. We can flip the second reaction and add it to the first reaction to get



$$E^\circ = -0.13 - (-0.44) = 0.31 \text{ V}$$

Thus, we see that **L^{2+} oxidizes M**, so the answer is **A**.

B is incorrect because for M to reduce N^{2+} , we must flip the second reaction. Then we have $-0.76 + 0.44 < 0$, so this is not spontaneous.

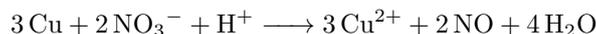
C is false because a reducing agent is oxidized. We see that we must flip the reactions to obtain an oxidation reaction. Then we see that $-0.76 < 0.44$, so N is a better reducing agent than M.

Similarly for D, $-0.13 > -0.44$ so L^{2+} ions are better oxidizing agents than M^{2+} ions. You may get the same conclusion using $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} > 0$ for spontaneous reactions. Please note oxidation occurs at the anode.

39. We must balance not only the elements, but also the charges. Notice that Cu is oxidized to Cu^{2+} by nitrogen, which is reduced from a $+5$ oxidation state in NO_3^- to a $+2$ oxidation state in NO. Thus two electrons leave each copper and three join each nitrogen. To make it six each, we multiply each copper by 3 and each nitrogen by 2.



Now we must balance the oxygens. There are 6 on the left side and 3 on the right side. We don't want to mess up the nitrogens, so we can add 3 oxygens by adding 3 more H_2O .



Finally, we balance the hydrogens. We need 8 on both sides.



A quick check confirms that both sides have a charge of $+6$. 2 and 3 are both prime so these are smallest whole number coefficients. The number of H^+ ions is **8**, or **D**.

40. We want the electrons to cancel out, so we must flip the second reaction. We don't change the magnitude of the potentials, only the signs. Thus the final potential is $0.80 - (-0.28) = \mathbf{1.08 \text{ V}}$, which is **B**.

41. We see from the line notation that Sn is oxidized and Cu is reduced. Thus the reaction is



Since the solid Sn and Cu do not affect the equilibrium expression, we focus on the aqueous ions. If we $\boxed{\text{increase}[\text{Cu}^{2+}]}$, equilibrium will shift right, increasing the voltage. Thus the answer is \boxed{D} .

42. We know that $n = 2$ because there are two electrons for each nickel. We must use Faraday's constant $F = 96500 \text{ C mol}^{-1}$ from the reference that comes with the olympiad.

$$1.30 \text{ g Ni} \times \frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}} \times \frac{2 \text{ mol } e^-}{\text{mol Ni}} \times \frac{96500 \text{ C}}{\text{mol } e^-} \times \frac{1 \text{ s}}{5.00 \text{ C}} = \boxed{8.55 \times 10^2 \text{ s}}$$

Thus, the answer is \boxed{C} .

43. For this question we must memorize our nuclear decay pathways. Alpha emission does not occur because $Z < 83$. There are 8 neutrons but only 6 protons, so this is a proton deficient element. Therefore, it will undergo electron emission to produce the stable ^{14}N , which is also called $\boxed{\text{beta emission}}$, so the answer is \boxed{B} .

44. Focusing on $n = 4$ and $l = 1$, we know this is an electron in a $4p$ orbital. Looking at the periodic table, we see that the only answer in the $4p$ block is $\boxed{\text{Se}}$, or \boxed{D} . Fe is $3d$, In is $5p$, and Pd is $4d$.

45. The first electrons to be lost will be those farthest from the nucleus, or the $4s$ electrons. After these two are lost, a $3d$ electron will be lost. Thus, the correct electron configuration is $\boxed{1s^2 2s^2 2p^6 3s^2 3p^6 3d^5}$ answer is \boxed{A} .

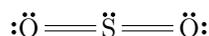
46. Imagining element 119 on the periodic table, we see it will be in Group I. Elements in the same group tend to have similar properties. $\boxed{\text{Fr}}$ is also in Group I, so the answer is \boxed{B} .

47. From our periodic trends, we are looking for the atom that is farthest from the top right. Looking at the periodic table we see this is $\boxed{\text{Se}}$, or \boxed{C} .

48. From our periodic trends, we are looking for the atom that is closest to the top right. Looking at the periodic table we see this is $\boxed{\text{Be}}$, or \boxed{B} .

49. A metal and a nonmetal tend to form non-covalent bonds. A and D have a metal and a nonmetal, so these can be eliminated. We know B is an ionic bond between ammonium (NH_4^+) and nitrate (NO_3^-), so this can be eliminated. $\boxed{\text{H}_2\text{SO}_4}$ consists of all covalently bonded nonmetals. Thus the answer is \boxed{C} .

50. Let's draw the Lewis structure for $\boxed{\text{SO}_2}$.



The central sulfur has two bonding groups and one lone pair. Thus, it is sp^2 hybridized, and the answer is \boxed{D} .

51. We want all the formal charges to be as close to 0 as possible. To find the formal charge, we take the number of valence electrons, and subtract the number of bonds and electron dots.

A has sulfur with a formal charge of $6 - 4 = +2$, so this can be eliminated.

B has an oxygen (the right one) with a formal charge of $6 - 6 - 2 = -2$, so this can be eliminated.

C has sulfur with a formal charge of $6 - 3 = +3$, so this can be eliminated.

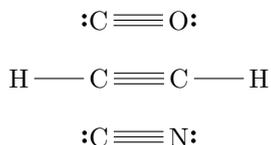
\boxed{D} has sulfur with a formal charge of $6 - 3 - 2 = +1$ and each oxygen with a formal charge of $6 - 6 - 1 = -1$. This is the closest to 0, and so, it is the correct answer.

If you pay closer attention to the sum of formal charge of each atom in each Lewis structure, you may realize that the first three structures are invalid as the sum is not -2 , the charge of SO_3^{2-} . Only D is a valid structure though it is

not the most stable resonance. In the most stable resonance of SO_3^{2-} , the central S connects to the one S=O and one S-O bonds, and has one lone pair, the double bonded oxygen has two lone pairs, while the single bonded oxygen has three lone pairs.

52. Each hydrogen has an oxidation state of +1, each fluorine and chlorine has an oxidation state of -1, and each oxygen has an oxidation state of -2. The sum of all oxidation states must be 0. Thus we see that the oxidation states of A, B, C, and D are +2, +4, +4, and +6 respectively. The lowest one is $\boxed{\text{SCl}_2}$, or \boxed{A} .

53. Each of the structures has a triple bond.



Thus the answer is $\boxed{\text{I, II, and III}}$, or \boxed{D} .

54. In A, C, and D, the molecular geometry is linear, tetrahedral, and trigonal bipyramidal, respectively, which are all symmetric. So the dipole moments of the polar bonds cancel out, making the overall dipole moment zero. $\boxed{\text{AsH}_3}$ has three bonding pairs and a lone pair on the As, which makes it a trigonal pyramidal structure. The three As-H bonds do not cancel out completely. Thus, the answer is \boxed{B} .

55. From the name, we know that $\boxed{\text{propyne}}$ is an alkyne. This means that it will have a triple bond and bond to the fewest hydrogens. So the hydrocarbons with double bond(s) or triple bond(s) are also called unsaturated as they have less hydrogens than the alkanes with the same number of carbons. Thus, the answer is \boxed{D} .

56. Since both are forms of pentane, they have the same number of carbon atoms (5) and the same geometry of the carbon chain. They also both have one chlorine atom. The number 2 or 3 indicates which of the 5 carbon atoms the chlorine is bonded to. Thus, the difference arises from the $\boxed{\text{position of the chlorine atom in the molecule}}$, and the answer is \boxed{C} .

57. Alanine is one of the 20 $\boxed{\text{amino acids}}$ that can be translated from the genetic code to form proteins. Thus, the answer is \boxed{A} .

58. A primary alcohol is a hydroxyl group attached to CH_2 . A secondary alcohol is a hydroxyl group attached to CH . A tertiary alcohol is a hydroxyl group attached to C with no hydrogens. Attachment to C_1 or C_4 would create a primary alcohol because there is still space for hydrogens. Attachment to C_2 would create a tertiary alcohol because the hydroxyl group would replace the hydrogen that the C_2 was bonded to. Attachment to $\boxed{\text{C}_3}$ would create a secondary alcohol because it would have two bonds for carbons, one for hydrogen, and one for the hydroxyl. Thus, the answer is \boxed{C} .

59. The $-\text{COOH}$ in the top right is a carboxyl group, which is an acid. Thus the $-\text{OH}$ is part of a larger carboxyl group rather than forming an alcohol. In the bottom left, there is an $-\text{C}(\text{O})\text{O}-$ which is an ester. There is no ether group because the O near the center is not bonded to two alkyl groups. Thus, the answer is $\boxed{\text{I and III}}$, or \boxed{A} .

60. We can eliminate D as vitamins are not one of the main sources of biological energy. $\boxed{\text{Fat}}$ provides twice the energy of carbohydrates or proteins. Thus, the answer is \boxed{B} .