

41. **D** - This is a stoichiometry problem, where the number of grams of sulfuric acid needs to be converted into moles of oxygen. Though there is 1 mole of sulfur in sulfuric acid, 1 mole of sulfur would be 6.02×10^{23} atoms. Likewise, there are not 16g of oxygen, instead there are 64 grams of oxygen in one mole of sulfuric acid. The best way to tackle this problem is to convert the number of grams of sulfuric acid into moles of oxygen.

$$49 \text{ grams H}_2\text{SO}_4 \times \frac{1 \text{ mol sulfuric acid}}{98 \text{ g sulfuric acid}} \times \frac{4 \text{ mol Oxygen}}{1 \text{ mol sulfuric acid}} = 2 \text{ mol O}$$

42. **A** - This is a limiting reagent problem. There is 1 mole of nitrogen and 1 mole of hydrogen, however according to the chemical equation, 1 mole of nitrogen is needed for every 3 moles of hydrogen. Thus, the limiting reagent is hydrogen. The amount of ammonia that can be produced is determined as follows:

$$1 \text{ mole H}_2 \times \frac{2 \text{ mol ammonia}}{3 \text{ mol hydrogen}} = 2/3 \text{ moles of ammonia}$$

43. **B** - The mass of the liquid can be determined by subtracting $328\text{g} - 95\text{g}$. A proportion can be written relating the mass of the liquid to the volume the liquid occupies.

$$\frac{200 \text{ mL}}{328\text{g}-95\text{g}} = \frac{x \text{ mL}}{1000\text{g}}, \text{ then cross multiply to solve for the unknown volume, resulting in:}$$

$$(200)(1000) = (328-95) (x\text{mL}), \text{ dividing to solve for } x, \text{ gives: } \frac{(200)(1000)}{(328-95)}$$

44. **D** - To determine the amount of nitrogen present in the compound, subtract the amount of oxygen present 2.22g from the total sample amount of 3.00g. To calculate the percent of nitrogen in the compound, divide the amount of nitrogen present ($3.00\text{g}-2.22\text{g}$) by the total weight of the compound, 3.00g and multiply by 100.

$$\% \text{ Nitrogen} = \frac{(3.00\text{g}-2.22\text{g})}{3.0\text{g}} (100)$$

45. **D** - This question deals with the combined gas law, with the left side of the equation being the initial state and the right side of the equation being the final state. Note: the temperature must be in Kelvin, not the Celsius that is mentioned in the question. To convert temperature to Kelvin, add 273 to the Celsius temperature.

$$\frac{PV}{T} = \frac{PV}{T} \rightarrow \frac{(1 \text{ atm})(10\text{L})}{(273+100)} = \frac{(0.5 \text{ atm})(x)}{(273+27)}, \text{ cross multiplying results in:}$$

$$(300)(1)(10) = (373)(0.5)(x), \text{ dividing by } (373) \text{ and } (0.5) \text{ gives the final answer of:}$$

$$= \frac{(300)(1)(10)}{(373)(0.5)}$$

46. **E** - According to Boyle's Law, when the volume is decreased the pressure increases because the particles are closer together and strike each other and the container

more often. The particles are not moving slower or faster since the temperature does not change and therefore the kinetic energy also does not change. The weight of the gas particles does not change, only the frequency of the collisions between the gas particles with each other and the inside of the container.

47. **A** - Water has a relatively low molar mass, but has a higher boiling point than other compounds with similar weight because of water's strong intermolecular forces. In particular, water has hydrogen bonding, which is a strong intermolecular force and as such a high amount of heat is needed to break these attractive forces and allow liquid water to evaporate to form water vapor. Therefore, the boiling point of water is higher than other similarly sized compounds.
48. **B** - The substance described is non-conducting meaning a non-electrolyte while it is a solid, but conducts electricity in its molten form. If the substance were metallic, it would conduct electricity as a solid and in its molten form. The solid is also soluble in water, therefore eliminating molecular and macromolecular. Though some molecular compounds can dissolve in water, molecular compounds are not electrolytes in any form. Ionic compounds are soluble in water and only conduct electricity in their dissolved form.
49. **C** - To solve this problem, the molarity equation is needed to solve for the number of moles in the solution. Note: the volume of solution must be in liters, not the milliliters given in the problem. Convert milliliters to liters by dividing the number of milliliters by 1000.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}} \rightarrow 0.4 = \frac{\text{moles of NaOH}}{0.250\text{L}} \rightarrow (0.4)(0.250) = \text{moles of NaOH}$$

Next, convert the number of moles into grams, using the molar mass provided.

$$(0.4)(0.250) = \text{moles of NaOH} \rightarrow 0.1 \text{ moles NaOH} \times \frac{40\text{g NaOH}}{1 \text{ mole NaOH}} = 4 \text{ g NaOH}$$

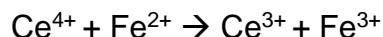
50. **C** - This question uses the dilution formula of $M_1V_1 = M_2V_2$, where the left side of the equation is for the initial conditions and the right side of the equation is the final conditions. Substituting the numbers given in the question, results in:

$(0.6)(400) = (0.5)(x)$, dividing by 0.5 gives the final volume of the solution.

$$\frac{(0.6)(400)}{0.5}$$

51. **C** - For this question, it is easiest to work backward from the answer options. For each answer option, there are ions in the equation. Remember, when dealing with ions, the charges on each side should equal each other. For example, if the right side has a total charge of +1, then the left side must also have a total charge of +1. Answer option A does not have balanced charges. Next, examine the change in the charges of the ions on the reactant side in comparison to the product side of the

equation. Cerium and Iron exchange one electron with Iron donating an electron to Cerium. Therefore the correct equation should have been:



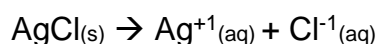
Note: In answer option E, the compound changes from Cerium (Ce) to Cesium (Cs) which is not the same element. In this reaction the element should not have changed only the charge of the ion.

52. **A** - The equation $M_{\text{acid}}V_{\text{acid}}n_{\text{acid}} = M_{\text{base}}V_{\text{base}}n_{\text{base}}$ can be used to determine the molarity of a compound in a neutralization reaction. Neutralization reactions involve combining an acid and a base to produce water and a salt. A monoprotic acid is an acid with 1 hydrogen, like HCl or HNO_3 . For the above equation the "n" represents the number of hydrogen (H) for acids and the number of hydroxide (OH^-) for bases. Substituting the values given in the question gives:

$$M_{\text{acid}}V_{\text{acid}}n_{\text{acid}} = M_{\text{base}}V_{\text{base}}n_{\text{base}} \rightarrow (X)(0.035)(1) = (0.5)(0.025)(1)$$

Solving for x by dividing by 0.035 results in: $\frac{(0.5)(0.025)}{0.035}$

53. **D** - Acids, in accordance with Bronsted Lowry, are said to be proton donors, giving away an H^+ . Whereas a base is a donor acceptor, receiving a proton or H^+ . In this question, water is behaving as the acid and is donating a hydrogen in the chemical reaction to form OH^- . When water forms the hydronium ion or H_3O^+ , water is behaving as a base, not an acid and is accepting a hydrogen. The only equation that produces OH^- which is indicative of water behaving as an acid, is answer option D.
54. **A** - In accordance to LeChatelier's principle, a reaction will shift to achieve equilibrium when the system is disturbed. In this question, if pressure is increased, the reaction will shift to the side with fewer particles to compensate for the increase in pressure which also decreases the volume. Answer options B, C, and E if shifted to the right would produce more particles which does not fit with the increase in pressure described in the question. Answer option D has the same number of particles on either side, therefore a change in the pressure would not result in a shift to either side. Answer option A is the only equation that would shift to the right, which is the side with fewer particles.
55. **E** - The solubility product constant (K_{sp}) is calculated by dividing the concentration of the products by the concentration of the reactants, applying any coefficients as exponents in the solubility product expression. Solids are not included in solubility product expressions, therefore the correct K_{sp} would be: $[\text{Ag}]^2[\text{SO}_4^{2-}]$.
56. **E** - For the decomposition of AgCl, the following equation would result:



The subsequent solubility product expression (K_{sp}) would be: $K_{sp} = [Ag^{+1}][Cl^{-1}]$. If the concentration of each of the ions is 1.0×10^{-6} then the K_{sp} would be: $[1.0 \times 10^{-6}][1.0 \times 10^{-6}]$ or $[1.0 \times 10^{-6}]^2$.

57. **C** - To determine the total enthalpy of the reaction, the sum of the enthalpies of the products and the reactants must be determined following the formula:

$$\Delta H_{rxn} = \text{Sum}(\Delta H_{\text{products}}) - \text{Sum}(\Delta H_{\text{reactants}})$$

Note: Any coefficients in the balanced equation must also be multiplied by the compound's heat of formation or standard enthalpy.

$$\Delta H_{rxn} = [6CO_2 + 6H_2O] - [C_6H_{12}O_6 + 6O_2]$$

$$\Delta H_{rxn} = [6(-94) + 6(-68)] - [-297 + 6(0)]$$

$$\Delta H_{rxn} = 6(-94) + 6(-68) - (-297)$$

58. **C** - Entropy is the amount of disorder in a system. Processes that decrease the amount of disorder, therefore increase the amount of organization in the system. This is achieved through cooling processes like freezing, condensation and through reactions that result in fewer products than reactants. The shuffling of a deck of cards increases the disorder as the cards are no longer in a specific order. The sublimation of carbon dioxide increases the entropy as the particles go from solid to gas. Compounds in their gaseous state have higher entropies than in their solid or liquid forms. Freezing liquid water to form ice would result in a decrease in entropy as the particles would become more organized in the ice structure.
59. **D** - If the compound dissolves for 5 minutes and decomposes at a rate of 0.040 M per minute, then after 5 minutes 0.20M of the reactant has decomposed (5×0.040). If the original molarity of the reactant was 0.50M and 0.20M has decomposed, then only 0.30M of the original reactant remains.
60. **A** -When the concentration of B is doubled the rate is quadrupled because reactant B is to the second order. In other words since $\text{rate} = k[A][B]^2$ assuming A's concentration is unchanged, the rate equation would now become $\text{rate} = k[B]^2$, substituting a 2 for doubling the concentration of B results in the rate equation, $\text{rate} = k[2]^2$, which results in an increase of the reaction rate by 4 times.
61. **E** - A reducing agent is itself oxidized which means it loses electrons. The reducing agent should show an increase in the charge as it signifies the lose of an electron(s). The reducing agent is among the reactants not the products, therefore eliminating answer options C and D. Hydrogen is neither oxidized or reduced as it retains its +1 charge on both sides of the equation. In dichromate, $Cr_2O_7^{2-}$, each oxygen has an oxidation number of -2, which means that all the oxygens in the compound have a charge of -14. Also, since there are 2 chromiums and the overall charge of the

compound is -2, each chromium must have a charge of +6. On the right side, chromium has a charge of +3, which is lower than the original +6 charge (on the left), therefore chromium has gained electrons or been reduced, not oxidized as would occur if $\text{Cr}_2\text{O}_7^{2-}$ were the reducing agent. The iodide ion, I^- , has an oxidation number of -1, but is converted to I_2 which has an oxidation number of 0. The iodide ion is the reducing agent (loses electrons and becomes more positive) and is oxidized in the chemical reaction.

62. **C** - Looking at the final equation and rearranging the given steps is essential in solving this problem. In the final chemical equation, 2Cl^- is on the left side of the reaction, but in the step above, the 2Cl^- is on the right side of the equation. Thus the top step needs to be reversed. When the equation is reversed, the E° must be multiplied by -1 to become -1.36v. Thereby, adding the two equations and the E° of each reaction together, yields the desired final equation and the resulting E° of the reaction:



63. **B** - For this problem, it is important to remember that the oxidation number of oxygen is always -2 and the oxidation number of hydrogen is always +1. To calculate the oxidation number of nitrogen, the oxidation number of the other element(s) in the compound must be considered and the overall charge of the compound has to be taken into account.

For example, in answer option A:

For N_2O_3 , the oxygens each have an oxidation number of -2, resulting in a total oxidation number for oxygen of -6. Since the compound is neutral, the overall charge must be zero. Therefore the 2 nitrogens must cancel the -6 charge of the oxygens, so each nitrogen must have an oxidation number of +3. Likewise for the HNO_3 (from answer option A), hydrogen has an oxidation number of +1 and oxygen has an oxidation number of -2. So, the oxygens contribute -6 and the hydrogen adds a +1, resulting in a left over oxidation charge of -5. Therefore to maintain the neutrality of the compound nitrogen must have an oxidation number of +5. In this answer option the oxidation number of each nitrogen in N_2O_3 and HNO_3 are not the same, +3 in N_2O_3 and +5 in HNO_3 . To find the correct pairing, continue this process to determine the set of nitrogenous compounds that have the same oxidation number for nitrogen.

64. **E** - The Lewis dot diagram of each compound must be written. Looking at the answer options, H_2O and H_2Se can be eliminated. Remember, the molecular shape of water is considered to be tetrahedral-bent. Since selenium (Se) is in the same column with oxygen, it has the same number of valence electrons and would

combine with hydrogen in a similar fashion to water, yielding another tetrahedral-bent structure. SO_2 forms a double bond on one oxygen, a single bond with the other oxygen, and still has an unbounded pair of electrons on the central atom (S). This would be categorized as a trigonal planar-bent molecule, as there are three domains (2 bonded and 1 non-bonded). Only CO_2 forms a linear shape, with the carbon being double bonded to both oxygen molecules, with no unbounded electrons on the central carbon atom.

65. **A** - Isotopes are variations of an element that possess the same number of protons and electrons, but only differ in the number of neutrons. If the number of neutrons varies so to does the atomic weight of the atom. The number of electrons is increased or decreased in an ion, resulting in an anion or a cation. The number of protons never changes and can be used to identify the element.
66. **C** - Resonance structures result when a multiple bond (usually a double bond) can be written in multiple ways resulting in a similar Lewis dot diagram. In the Lewis structure of NO_3^- , a double bond is formed between the nitrogen and one of the oxygen atoms. Since the oxygen atoms are all identical, the double bond can be formed between any of the oxygens in the structure, therefore NO_3^- has a total of 3 different resonance structures that can be written.
67. **B** - The highest orbital in the electron configuration given is the 3p subshell. The p subshell has 3 orbitals and can hold a maximum of 6 electrons. In accordance with Hund's rule, electrons must occupy an orbital first before pairing up. In this question, the 3p subshell has 2 electrons, therefore one electron would be placed in each orbital first, leaving the 3rd p orbital empty and the two occupied orbitals with one electron each, that is unpaired. Therefore a total of two electrons are unpaired.
68. **B** - Period 2 corresponds with the second row on the periodic table. As one goes across the periodic table from left to right (with increasing atomic number), the electronegativity increases. The electronegativity is the ability of an element to attract electrons. Metals have a lower electronegativity than non-metals. As one moves from left to right from metals to non-metals, electronegativity becomes larger. Atomic radius in this direction would decrease due to non-metals being able to attract outer electrons to the nucleus, therefore compacting their size. Also, the metallic character decreases across the period as one moves from metals to non-metals.
69. **E** - The electronegativity of elements varies greatly between metals and non-metals. The closer the elements are on the periodic table the smaller the difference in electronegativity will be and the less ionic character the compounds will have. Ionic character is determined by combining a metal and a non-metal together in a compound. Answer options B, C, and D are all combinations of non-metals and would have the least ionic character. Aluminum (Al) and sulfur (S) are closer on the periodic table than lithium (Li) and oxygen (O). Though both Al and S and Li and O

are examples of ionic compounds, Li and O would have the most ionic character as these elements are the furthest apart on the periodic table.

70. **D** - This is an example of a nuclear fission equation, where an isotope is decomposing to form an electron and another element. The superscripts and subscripts have to be equal on both sides. In the nuclide form shown in the answer options, the top number (superscript) is the atomic weight of the element and the bottom number (subscript) is the atomic number. Therefore, the missing element must have an atomic number of 6. The atomic number can be used to identify the element needed to complete the equation. Carbon (C) has an atomic number of 6, thus the following equation results: ${}^{13}_7\text{N} \rightarrow {}^0_{+1}e + {}^{13}_6\text{C}$.