Name:________________________________

Answer Key for AP Chemistry Practice Exam, Section I

Question 1:	D
Question 2:	B
Question 3:	C
Question 4:	B
Question 5:	B
Question 6:	D
Question 7:	A
Question 8:	B
Question 9:	B
Question 10:	D
Question 11:	C
Question 12:	D
Question 13:	B
Question 14:	B
Question 15:	D
Question 16:	D
Question 17:	D
Question 18:	C
Question 19:	B
Question 20:	D
Question 21:	B
Question 22:	B
Question 23:	A
Question 24:	B
Question 25:	A

Question 26:	A
Question 27:	B
Question 28:	C
Question 29:	B
Question 30:	D
Question 31:	D
Question 32:	C
Question 33:	D
Question 34:	D
Question 35:	B
Question 36:	D
Question 37:	D
Question 38:	D
Question 39:	C
Question 40:	C
Question 41:	B
Question 42:	C
Question 43:	B
Question 44:	A
Question 45:	C
Question 46:	C
Question 47:	A
Question 48:	D
Question 49:	B
Question 50:	D

Multiple-Choice Section for Chemistry Course Framework Alignment and Rationales

Question 1

Skill	Learning Objective	Topic
1.A	9.1.A	Introduction to Entropy

(A)	Incorrect. ΔS for evaporation is positive because the C_2H_5OH molecules in the gas phase can act independently and are distributed over a greater volume than are the molecules in the liquid phase.
(B)	Incorrect. ΔS for the melting of NaCl(*s*) is positive because ions in fixed positions in the solid phase can now move freely among the other ions in the liquid phase.
(C)	Incorrect. ΔS for the sublimation of $CO_2(s)$ is positive because the molecules in the gas phase can act independently and are distributed over a greater volume than are the molecules in the solid phase.
(D)	**Correct**. ΔS for the condensation of $Cl_2(g)$ has a negative value because gas molecules become restricted to a much smaller volume as they condense to the liquid phase.

Question 2

Skill	Learning Objective	Topic
4.C	3.7.A	Solutions and Mixtures

(A)	Incorrect. Although molecules of $HC_2H_3O_2$ do contain the greatest number of atoms, $HC_2H_3O_2(aq)$ dissociates into H^+ ions and $C_2H_3O_2^-(aq)$ ions to a much-smaller extent than the $K^+(aq)$ and $I^-(aq)$ ions in KI(*aq*); thus, $HC_2H_3O_2(aq)$ is a weaker conductor than KI(*aq*).
(B)	**Correct**. KI(*aq*) has the greatest conductivity because KI dissociates completely in water, producing mobile $K^+(aq)$ and $I^-(aq)$ ions that can move through the solution and carry an electrical current.
(C)	Incorrect. Although CH_3OH molecules can form hydrogen bonds among themselves and with water molecules, they do not dissociate into charged particles that could carry an electrical current. Thus, $CH_3OH(aq)$ is not an electrolyte.
(D)	Incorrect. Electrical conductivity of solutions depends on whether or not the solutes are electrolytes in addition to the concentrations of solutes.

Question 3

Skill	Learning Objective	Topic
4.A	7.2.A	Direction of Reversible Reactions

(A)	Incorrect. Only the rate of the forward reaction increases.
(B)	Incorrect. The rate of the forward reaction changes, specifically by increasing.
(C)	**Correct**. The introduction of more $I_2(g)$ molecules to the system increases the likelihood of a collision between molecules of $I_2(g)$ and $H_2(g)$, which is a necessary step for the reaction to occur. The greater number of such collisions increases the rate of the forward reaction.
(D)	Incorrect. The rate of the forward reaction becomes greater than the rate of the reverse reaction.

Question 4

Skill	Learning Objective	Topic
6.E	1.7.A	Periodic Trends

(A)	Incorrect. The difference between the first and second ionization energies is much smaller than the difference between the third and fourth ionization energies, which indicates that the element is Al, not Na.
(B)	**Correct**. The increase between the third and fourth ionization energies is much greater than the differences between the other successive ionization energies. This indicates that the fourth electron removed from the atom is in an energy subshell (2*p*) that is substantially lower in energy than the subshell from which the first three electrons were removed (3*s* and 3*p*). This is true for the element Al, which has exactly three electrons in the third ($n = 3$) energy level.
(C)	Incorrect. Although it is true that the fifth ionization energy has the greatest value, it is the <u>difference</u> between successive ionization energies that provides data for determining the identity of an element. The largest difference occurs between the third and fourth ionization energies, which indicates that the element is Al, not Si.
(D)	Incorrect. Although it is true that a neutral P atom has five valence electrons, it is the difference between successive ionization energies that provides data for determining the identity of an element. The largest difference occurs between the third and fourth ionization energies, which indicates that the element is Al, not P.

Question 5

Skill	Learning Objective	Topic
6.C	3.1.A	Intermolecular and Interparticle Forces

(A)	Incorrect. The negative ends of the water-molecule dipoles are directed away from the particle, not toward it. The central particle has a negative charge, which identifies it as an anion.
(B)	**Correct**. The positive end of the permanent dipole of a water molecule is centered between the two hydrogen atoms. Because all the water molecules are arranged with the positive ends of their dipoles oriented toward the central particle, the central particle must have a negative charge, which identifies it as an anion.
(C)	Incorrect. Although water molecules have no net charge, the distribution of charge in the water molecule is uneven—water molecules have a permanent dipole. Because all the water molecules are arranged with the positive ends of their dipoles oriented toward the central particle, the central particle must have a negative charge, which identifies it as an anion.
(D)	Incorrect. The partial charges of the water molecules (which give rise to the dipoles) do not necessarily cancel when the whole system consisting of the central particle and the surrounding water molecules is considered because of random molecular motion. However, the charge of the particle is still easily determined because of the orientation of the water-molecule dipoles.

Question 6

Skill	Learning Objective	Topic
6.E	3.9.A	Separation of Solutions and Mixtures

(A)	Incorrect. Filtration would not work at all because both hexane and octane molecules would pass through the relatively huge pores in the filter paper with the same ease. Also, filtration separates mixtures based on particle size, not density.
(B)	Incorrect. Paper chromatography separates components of mixtures based on differences between affinities of the components for the paper (stationary phase) and the solvent (mobile phase). Both hexane and octane have nonpolar molecules with similar intermolecular forces that would not lead to sufficiently different affinities to allow separation using this method.
(C)	Incorrect. The masses of the molecules of the two components of the mixture are not a factor in how fast they would move through a column. Column chromatography separates components of mixtures based on differences between affinities of the components for the stationary phase (e.g., silica gel) and the mobile phase. Both hexane and octane have nonpolar molecules with similar intermolecular forces that would not lead to sufficiently different affinities to allow separation using this method.
(D)	**Correct**. The difference in boiling points between the two liquids would permit their separation by the process of distillation. In the vapor above a heated mixture of the two liquids, the compound with the lower boiling point (hexane) would predominate. When that vapor cools as it passes through a condenser, liquid hexane could be collected.

Question 7

Skill	Learning Objective	Topic
5.F	7.6.A	Properties of the Equilibrium Constant

(A)	**Correct**. The second equation can be obtained by simultaneously reversing the direction of the first equation and multiplying each of the coefficients in the equation by 2. The effect of the first transformation is to invert the value of *K* and the effect of the second transformation is to raise *K* to the power of 2. Therefore, the value of *K* for the second equation should have the value $\left(\frac{1}{K}\right)^2 = \frac{1}{K^2}$. Thus, the value of *K* for the second equation is $\left(\frac{1}{1\times10^{10}}\right)^2 = \frac{1}{1\times10^{20}} = 1\times10^{-20}$.
(B)	Incorrect. This choice is consistent with failing to recognize that the coefficients of the equation were multiplied by 2.
(C)	Incorrect. This choice makes the incorrect assumption that the value of *K* stays constant.
(D)	Incorrect. This choice is consistent with failing to recognize that the equation was reversed.

Question 8

Skill	Learning Objective	Topic
4.C	5.11.A	Catalysis

(A)	Incorrect. An enzyme does not function by consuming byproducts of the reaction. An enzyme is a catalyst, and as such it provides a different, lower energy pathway for the reaction to occur. The enzyme temporarily binds to the reactant or reactants, allowing the reaction to occur with less input of energy; then the enzyme is regenerated by the release of the product or products.
(B)	**Correct**. An enzyme is a catalyst, and as such it provides a different, lower energy pathway for the reaction to occur. The enzyme temporarily binds to the reactant or reactants, allowing the reaction to occur with less input of energy; then the enzyme is regenerated by the release of the product or products.
(C)	Incorrect. An enzyme does not function by breaking up into more reactant particles. An enzyme is a catalyst, and as such it provides a different, lower energy pathway for the reaction to occur. The enzyme temporarily binds to the reactant or reactants, allowing the reaction to occur with less input of energy; then the enzyme is regenerated by the release of the product or products.
(D)	Incorrect. An enzyme does not function by decomposing to produce energy. Enzymes are not used up as a reaction occurs, instead they are constantly regenerated. An enzyme is a catalyst, and as such it provides a different, lower energy pathway for the reaction to occur. The enzyme temporarily binds to the reactant or reactants, allowing the reaction to occur with less input of energy; then the enzyme is regenerated by the release of the product or products.

Question 9

Skill	Learning Objective	Topic
1.A	2.3.A	Structure of Ionic Solids

(A)	Incorrect. This diagram shows layers of alternating pairs of ions of the same charge. The repulsions between ions of the same charge in this arrangement would be very large and would not represent a stable configuration. An arrangement in which each ion of one charge was surrounded by ions of the opposite charge would be the most energetically favorable.
(B)	**Correct**. This diagram shows ions as being tightly packed surrounded by ions of the opposite charge, which is true in a crystal of an ionic compound such as KF. This arrangement represents the lowest energy state attainable by the constituent ions.
(C)	Incorrect. This diagram shows ions of the same charge in alternating layers. The repulsions among the ions in the same layer in this arrangement would be very large and would not represent a stable configuration. An arrangement in which each ion of one charge was surrounded by ions of the opposite charge would be the most energetically favorable.
(D)	Incorrect. This diagram shows ions widely dispersed and in a random arrangement, which could better represent KF in the gas phase, not solid KF.

Question 10

Skill	Learning Objective	Topic
5.E	4.2.A	Net Ionic Equations

(A)	Incorrect. The species $Ag^{2+}(aq)$ does not exist and is not present in the information provided.
(B)	Incorrect. This equation incorrectly shows $Ag^{+}(aq)$ and $Zn^{2+}(aq)$ as reactants. In the cell reaction, $Zn^{2+}(aq)$ is a product, not a reactant.
(C)	Incorrect. This equation is missing one $Ag^{+}(aq)$ on the left side and one $Ag(s)$ on the right side, and there is an extraneous electron on the right side.
(D)	**Correct**. A thermodynamically favorable reaction occurs when aqueous silver ion, $Ag^{+}(aq)$, oxidizes zinc metal, $Zn(s)$, as represented by the equation $2\ Ag^{+}(aq) + Zn(s) \rightarrow 2\ Ag(s) + Zn^{2+}(aq)$.

Question 11

Skill	Learning Objective	Topic
5.F	9.9.A	Cell Potential and Free Energy

(A)	Incorrect. This choice represents the simple addition of the $E°$ value for the two half-reactions.
(B)	Incorrect. This choice represents the result of adding the $E°$ value for the first half-reaction to the sum of the $E°$ values of the two half-reactions.
(C)	**Correct**. The correct reaction is obtained by doubling the first half-reaction in the table (but not doubling the value of $E°$) and adding the reverse of the second half-reaction (while reversing the sign of its $E°$). Thus, $E^{\circ}_{cell} = 0.80 - (-0.76) = 1.56$ V.
(D)	Incorrect. This choice represents the result of improperly doubling the $E°$ value of the first half-reaction before adding it to the $E°$ value of the second half-reaction.

Question 12

Skill	Learning Objective	Topic
5.F	4.5.A	Stoichiometry

(A)	Incorrect. In one day the astronaut exhales 880 $g = 20$ mol $CO_2(g)$. According to the balanced equation, the amount of LiOH(*s*) needed to react with 20 mol $CO_2(g)$ would be 40 mol LiOH(*s*). The mass of 40 mol LiOH(*s*) is $40 \text{ mol} \times 24 \text{ g/mol} = 960$ g LiOH(*s*).
(B)	Incorrect. In one day the astronaut exhales $880 \text{ g} = 20 \text{ mol}$ $CO_2(g)$. According to the balanced equation, the amount of LiOH(*s*) needed to react with 20 mol $CO_2(g)$ would be 40 mol LiOH(*s*). The mass of 40 mol LiOH(*s*) is $40 \text{ mol} \times 24 \text{ g/mol} = 960$ g LiOH(*s*).
(C)	Incorrect. In one day the astronaut exhales $880 \text{ g} = 20 \text{ mol}$ $CO_2(g)$. According to the balanced equation, the amount of LiOH(*s*) needed to react with 20 mol $CO_2(g)$ would be 40 mol LiOH(*s*). The mass of 40 mol LiOH(*s*) is $40 \text{ mol} \times 24 \text{ g/mol} = 960$ g LiOH(*s*).
(D)	**Correct**. In one day the astronaut exhales $880 \text{ g} = 20 \text{ mol}$ $CO_2(g)$. According to the balanced equation, the amount of LiOH(*s*) needed to react with 20 mol $CO_2(g)$ would be 40 mol LiOH(*s*). The mass of 40 mol LiOH(*s*) is $40 \text{ mol} \times 24 \text{ g/mol} = 960$ g LiOH(*s*).

Question 13

Skill	Learning Objective	Topic
5.B	5.3.A	Concentration Changes Over Time

(A)	Incorrect. The data show that the quantity $\frac{1}{[NO_2]}$ increases by the same amount (0.75L/mol) every 100 seconds, which means that plotting $\frac{1}{[NO_2]}$ versus time yields a straight line. According to the integrated rate laws, this result is consistent with the reaction being second order. Therefore, the rate law takes the form $rate = k[NO_2]^2$.
(B)	**Correct**. The data show that the quantity $\frac{1}{[NO_2]}$ increases by the same amount (0.75L/mol) every 100 seconds, which means that plotting $\frac{1}{[NO_2]}$ versus time yields a straight line. According to the integrated rate laws, this result is consistent with the reaction being second order. Therefore, the rate law takes the form $rate = k[NO_2]^2$.
(C)	Incorrect. The data show that the quantity $\frac{1}{[NO_2]}$ increases by the same amount (0.75L/mol) every 100 seconds, which means that plotting $\frac{1}{[NO_2]}$ versus time yields a straight line. According to the integrated rate laws, this result is consistent with the reaction being second order. Therefore, the rate law takes the form $rate = k[NO_2]^2$.
(D)	Incorrect. The data show that the quantity $\frac{1}{[NO_2]}$ increases by the same amount (0.75L/mol) every 100 seconds, which means that plotting $\frac{1}{[NO_2]}$ versus time yields a straight line. According to the integrated rate laws, this result is consistent with the reaction being second order. Therefore, the rate law takes the form $rate = k[NO_2]^2$.

Question 14

Skill	Learning Objective	Topic
6.C	1.6.A	Photoelectron Spectroscopy

(A)	Incorrect. The two valence electrons in He are in the same (1*s*) energy level as that occupied by the valence electron of H. However, the He nucleus has two protons. The greater nuclear charge of He increases the attraction of its two electrons to the nucleus, increasing their binding energy, which moves the peak to the left. The peak is twice the height of the peak for H because there are twice as many electrons in the 1*s* orbital of the He atom than in the 1*s* orbital of the H atom.
(B)	**Correct**. The He nucleus has two protons. The greater nuclear charge of He increases the attraction of its two electrons to the nucleus, increasing their binding energy, which moves the peak to the left. The peak is twice the height of the peak for H because there are twice as many electrons in the 1*s* orbital of the He atom than in the 1*s* orbital of the H atom.
(C)	Incorrect. The distance of the valence electrons from the nucleus is less in He than in H, not greater. However, the He nucleus has two protons. The greater nuclear charge of He increases the attraction of its two electrons to the nucleus, increasing their binding energy, which moves the peak to the left. The peak is twice the height of the peak for H because there are twice as many electrons in the 1*s* orbital of the He atom than in the 1*s* orbital of the H atom.
(D)	Incorrect. The masses of the two atoms have nothing to do with the amount of time it takes to remove an electron from either one. However, the He nucleus has two protons. The greater nuclear charge of He increases the attraction of its two electrons to the nucleus, increasing their binding energy, which moves the peak to the left. The peak is twice the height of the peak for H because there are twice as many electrons in the 1*s* orbital of the He atom than in the 1*s* orbital of the H atom.

Question 15

Skill	Learning Objective	Topic
5.E	4.5.A	Stoichiometry

(A)	Incorrect. By the law of conservation of mass, the missing atoms on the left side of the equation must be 4 carbon atoms, 8 hydrogen atoms, and 2 oxygen atoms. Therefore, the molecular formula of the unknown compound is $C_4H_8O_2$.
(B)	Incorrect. By the law of conservation of mass, the missing atoms on the left side of the equation must be 4 carbon atoms, 8 hydrogen atoms, and 2 oxygen atoms. Therefore, the molecular formula of the unknown compound is $C_4H_8O_2$.
(C)	Incorrect. By the law of conservation of mass, the missing atoms on the left side of the equation must be 4 carbon atoms, 8 hydrogen atoms, and 2 oxygen atoms. Therefore, the molecular formula of the unknown compound is $C_4H_8O_2$.
(D)	**Correct**. By the law of conservation of mass, the missing atoms on the left side of the equation must be 4 carbon atoms, 8 hydrogen atoms, and 2 oxygen atoms. Therefore, the molecular formula of the unknown compound is $C_4H_8O_2$.

Question 16

Skill	Learning Objective	Topic
6.E	6.7.A	Bond Enthalpies

(A)	Incorrect. The actual number of bonds in products and reactants, per se, does not control the exothermicity or endothermicity of the reaction. It is the sum of the <u>energies</u> of the bonds that matters. In an exothermic reaction, more energy is released as new bonds in the product molecules form than is required to break the bonds in the reactant molecules.
(B)	Incorrect. The actual number of bonds in products and reactants, per se, does not control the exothermicity or endothermicity of the reaction. It is the sum of the <u>energies</u> of the bonds that matters. In an exothermic reaction, more energy is released as new bonds in the product molecules form than is required to break the bonds in the reactant molecules.
(C)	Incorrect. If this were true, the reaction would be endothermic, not exothermic.
(D)	**Correct**. In an exothermic reaction, more energy is released as new bonds in the product molecules form than is required to break the bonds in the reactant molecules.

Question 17

Skill	Learning Objective	Topic
6.E	3.1.A	Intermolecular and Interparticle Forces

(A)	Incorrect. The ethane molecule is smaller (14 valence electrons) than the propanol molecule (26 valence electrons); thus, ethane has a smaller, less polarizable electron cloud than propanol has. Also, polarizability of electron clouds is more of a factor in determining London dispersion forces, which are generally weaker than dipole-dipole forces such as hydrogen bonding, which makes propanol more soluble in water than ethane is.
(B)	Incorrect. Although ethane molecules are smaller than propanol molecules, solubility is affected much more by intermolecular forces between solute and solvent molecules. Propanol molecules, which contain a hydroxyl (–OH) group, can interact more strongly with the polar solvent (H_2O) molecules than ethane molecules, which are nonpolar, can interact with the polar solvent (H_2O) molecules. Thus, the solubility of propanol in water is greater than the solubility of ethane in water.
(C)	Incorrect. Although propanol molecules have more mass than ethane molecules have, mass itself is not a factor in solubility, which is affected much more by intermolecular forces between solute and solvent molecules. Propanol molecules, which contain a hydroxyl (–OH) group, can interact more strongly with the polar solvent (H_2O) molecules than ethane molecules, which are nonpolar, can interact with the polar solvent (H_2O) molecules. Thus, the solubility of propanol in water is greater than the solubility of ethane in water.
(D)	**Correct**. Solubility depends on the nature and strengths of the intermolecular forces between solute and solvent molecules. Propanol molecules, which contain a hydroxyl (–OH) group, can interact more strongly with the polar solvent (H_2O) molecules than ethane molecules, which are nonpolar, can interact with the polar solvent (H_2O) molecules. Thus, the solubility of propanol in water is greater than the solubility of ethane in water.

Question 18

Skill	Learning Objective	Topic
5.F	6.6.A	Introduction to Enthalpy of Reaction

(A)	Incorrect. Although the molar heat of combustion of propanol is greater than that of ethane, 30.0 g of ethane represents one mole and 30.0 g of propanol represents one-half of a mole. According to the data in the table, the combustion of the ethane releases 1560 kJ, whereas the combustion of the propanol releases only one-half of 2020 kJ, or 1010 kJ. Because 1560 kJ > 1010 kJ, $q_{ethane} > q_{propanol}$.
(B)	Incorrect. Although the molar heat of combustion of propanol is greater than that of ethane, 30.0 g of ethane represents one mole and 30.0 g of propanol represents one-half of a mole. According to the data in the table, the combustion of the ethane releases 1560 kJ, whereas the combustion of the propanol releases only one-half of 2020 kJ, or 1010 kJ. Because 1560 kJ > 1010 kJ, $q_{ethane} > q_{propanol}$
(C)	**Correct**. Although the molar heat of combustion of propanol is greater than that of ethane, 30.0 g of ethane represents one mole and 30.0 g of propanol represents one-half of a mole. According to the data in the table, the combustion of the ethane releases 1560 kJ, whereas the combustion of the propanol releases only one-half of 2020 kJ, or 1010 kJ. Because 1560 kJ > 1010 kJ, $q_{ethane} > q_{propanol}$.
(D)	Incorrect. The specific heat capacities of the compounds are not needed to calculate the heat released by their combustion. Although the molar heat of combustion of propanol is greater than that of ethane, 30.0 g of ethane represents one mole and 30.0 g of propanol represents one-half of a mole. According to the data in the table, the combustion of the ethane releases 1560 kJ, whereas the combustion of the propanol releases only one-half of 2020 kJ, or 1010 kJ. Because 1560 kJ > 1010 kJ, $q_{ethane} > q_{propanol}$.

Question 19

Skill	Learning Objective	Topic
4.A	3.5.A	Kinetic Molecular Theory

(A)	Incorrect. Since both gases are at the same temperature (400 K), the average kinetic energies of the ethane and propanol molecules are equal. However, because ethane molecules are less massive than propanol molecules, in order to have the same average kinetic energy $\left(\frac{1}{2}mv^2\right)$, the average molecular speed, v, of the ethane molecules must be greater than (not less than) that of the propanol molecules.
(B)	**Correct**. Since both gases are at the same temperature (400 K), the average kinetic energies of the ethane and propanol molecules are equal. However, because ethane molecules are less massive than propanol molecules, in order to have the same average kinetic energy $\left(\frac{1}{2}mv^2\right)$, the average molecular speed, v, of the ethane molecules must be greater than that of the propanol molecules.
(C)	Incorrect. Since both gases are at the same temperature (400 K), the average kinetic energies of the gases are equal. However, because ethane molecules are less massive than propanol molecules, in order to have the same average kinetic energy $\left(\frac{1}{2}mv^2\right)$, the average molecular speed, v, of the ethane molecules must be greater than (not the same as) that of the propanol molecules.
(D)	Incorrect. Pressure is irrelevant to the issue of comparing average molecular speeds, and it is possible to compare the average molecular speeds of the two gases. Since both gases are at the same temperature (400 K), the average kinetic energies of the gases are equal. However, because ethane molecules are less massive than propanol molecules, in order to have the same average kinetic energy $\left(\frac{1}{2}mv^2\right)$, the average molecular speed, v, of the ethane molecules must be greater than that of the propanol molecules.

Question 20

Skill	Learning Objective	Topic
6.D	9.3.A	Gibbs Free Energy and Thermodynamic Favorability

(A)	Incorrect. In fact, most endothermic processes are thermodynamically unfavorable. Because the dissolution process is endothermic, ΔH for the process is positive. The fact that the process occurs indicates that the process is favorable at 25°C; thus, ΔG for the process is negative. Algebraically, since $\Delta G = \Delta H - T\Delta S$, $\Delta G < 0$ implies that $\Delta S > 0$.
(B)	Incorrect. Stirring can supply a small amount of energy, but the process is driven by an increase in entropy, not enabled by supplying energy for the process to occur. Because the dissolution process is endothermic, ΔH for the process is positive. The fact that the process occurs indicates that the process is favorable at 25°C; thus, ΔG for the process is negative. Algebraically, since $\Delta G = \Delta H - T\Delta S$, $\Delta G < 0$ implies that $\Delta S > 0$.
(C)	Incorrect. This contradicts the given statement that the salt dissolves endothermically. Because the dissolution process is endothermic, ΔH for the process is positive. The fact that the process occurs indicates that the process is favorable at 25°C; thus, ΔG for the process is negative. Algebraically, since $\Delta G = \Delta H - T\Delta S$, $\Delta G < 0$ implies that $\Delta S > 0$.
(D)	**Correct**. Because the dissolution process is endothermic, ΔH for the process is positive. The fact that the process occurs indicates that the process is favorable at 25°C; thus, ΔG for the process is negative. Algebraically, since $\Delta G = \Delta H - T\Delta S$, $\Delta G < 0$ implies that $\Delta S > 0$.

Question 21

Skill	Learning Objective	Topic
6.E	8.8.A	Properties of Buffers

(A)	Incorrect. The anions Cl^- and $C_2H_3O_2^-$ do not react with each other. Furthermore, adding H^+ to a solution would lower its pH, not increase it.
(B)	**Correct**. The $C_2H_3O_2^-$ ion, as the anion of a weak acid, is itself a fairly strong base. So the addition of a small amount of H^+ ions will result in most of them reacting with $C_2H_3O_2^-$ ions to form the neutral species $HC_2H_3O_2$. In this way, the pH change in the solution is mitigated, and the pH decreases only slightly.
(C)	Incorrect. The increase in pH due to the addition of a small amount of OH^- ions will be mitigated because most of the added OH^- anions will react with $HC_2H_3O_2$ molecules, <u>not</u> $C_2H_3O_2^-$ ions, present in the solution.
(D)	Incorrect. The pH of the solution will <u>increase</u>, not decrease, only slightly because most of the added OH^- anions will react with $HC_2H_3O_2$ molecules present in the solution.

Question 22

Skill	Learning Objective	Topic
5.E	4.3.A	Representations of Reactions

(A)	Incorrect. This diagram violates the law of conservation of matter: four O atoms are missing. The reactants are initially present in equal amounts: four molecules each of H_2 and O_2. In the reaction product, H_2O, there are twice as many H atoms as O atoms; therefore, H_2 is the limiting reactant. When the reaction progresses to completion, all the H_2 molecules will be consumed, four H_2O molecules will be produced, and two O_2 molecules will remain unreacted.
(B)	**Correct**. The reactants are initially present in equal amounts: four molecules each of H_2 and O_2. In the reaction product, H_2O, there are twice as many H atoms as O atoms; therefore, H_2 is the limiting reactant. When the reaction progresses to completion, all the H_2 molecules will be consumed, four H_2O molecules will be produced, and two O_2 molecules will remain unreacted, as shown in the diagram for this option.
(C)	Incorrect. Although the stoichiometry is correct in this diagram, oxygen is represented by four single O atoms instead of two O_2 molecules. If the conditions corresponded to the presence of dissociated O_2 molecules, then the water molecules would also be dissociated.
(D)	Incorrect. This diagram violates the law of conservation of matter: there are eight extra H atoms present in the products. The reactants are initially present in equal amounts: four molecules each of H_2 and O_2. In the reaction product, H_2O, there are twice as many H atoms as O atoms; therefore, H_2 is the limiting reactant. When the reaction progresses to completion, all the H_2 molecules will be consumed, four H_2O molecules will be produced, and two O_2 molecules will remain unreacted.

Question 23

Skill	Learning Objective	Topic
5.F	5.3.A	Concentration Changes Over Time

(A)	**Correct**. For a first-order reaction, the half-life $\left(t_{\frac{1}{2}}\right)$ is related to the rate constant (k) by the equation $t_{\frac{1}{2}} = \frac{0.693}{k}$. Rearranging the equation, $k = \frac{0.693}{t_{\frac{1}{2}}} = \frac{0.693}{56\text{ days}} = 0.012\text{ day}^{-1}$.
(B)	Incorrect. For a first-order reaction, the half-life $\left(t_{\frac{1}{2}}\right)$ is related to the rate constant (k) by the equation $t_{\frac{1}{2}} = \frac{0.693}{k}$. Rearranging the equation, $k = \frac{0.693}{t_{\frac{1}{2}}} = \frac{0.693}{56\text{ days}} = 0.012\text{ day}^{-1}$.
(C)	Incorrect. For a first-order reaction, the half-life $\left(t_{\frac{1}{2}}\right)$ is related to the rate constant (k) by the equation $t_{\frac{1}{2}} = \frac{0.693}{k}$. Rearranging the equation, $k = \frac{0.693}{t_{\frac{1}{2}}} = \frac{0.693}{56\text{ days}} = 0.012\text{ day}^{-1}$.
(D)	Incorrect. For a first-order reaction, the half-life $\left(t_{\frac{1}{2}}\right)$ is related to the rate constant (k) by the equation $t_{\frac{1}{2}} = \frac{0.693}{k}$. Rearranging the equation, $k = \frac{0.693}{t_{\frac{1}{2}}} = \frac{0.693}{56\text{ days}} = 0.012\text{ day}^{-1}$.

Question 24

Skill	Learning Objective	Topic
5.D	2.2.A	Intramolecular Force and Potential Energy

(A)	Incorrect. At 25 pm the net force between the atoms is repulsive, and a bond is not formed. Rather, the minimum potential energy of the system corresponds to an internuclear distance of 75 pm, at which the bond is stable.
(B)	**Correct**. The minimum potential energy occurs at an internuclear distance of 75 pm, which corresponds to the length of the stable bond that forms between the two atoms. If the atoms were any closer to each other, the net force would be repulsive. Likewise, if the atoms were farther from each other, the net force would be attractive. At 75 pm, the net force between the two atoms is zero.
(C)	Incorrect. At an internuclear distance of 25 pm, the net force between the atoms is repulsive. A stable bond corresponds to an internuclear distance of 75 pm, where the potential energy of the system is as low as possible and the net force between the atoms is zero.
(D)	Incorrect. The net force between the atoms at an internuclear distance of 75 pm is zero. At this distance, the attractive forces between the atoms are exactly balanced by the repulsive forces.

Question 25

Skill	Learning Objective	Topic
5.C	3.4.A	Ideal Gas Law

(A)	**Correct**. As the balanced equation indicates, more moles of gas (18) are produced than the number of moles of gas consumed (15) as the reaction proceeds. Therefore, when the reaction is complete and the temperature and pressure are returned to their original values, the volume of gases in the cylinder must be greater (V is proportional to n when both T and P are held constant). Thus, the position of the piston in the cylinder will be higher than its original position.
(B)	Incorrect. Although mass is conserved during the reaction, as the balanced equation indicates, more moles of gas (18) are produced than the number of moles of gas consumed (15) as the reaction proceeds. Therefore, when the reaction is complete and the temperature and pressure are returned to their original values, the volume of gases in the cylinder must be greater (V is proportional to n when both T and P are held constant). Thus, the position of the piston in the cylinder will be higher than its original position.
(C)	Incorrect. Although it is true that the temperature and pressure of the gases in the cylinder before and after the reaction are the same, as the balanced equation indicates, more moles of gas (18) are produced than the number of moles of gas consumed (15) as the reaction proceeds. Therefore, when the reaction is complete and the temperature and pressure are returned to their original values, the volume of gases in the cylinder must be greater (V is proportional to n when both T and P are held constant). Thus, the position of the piston in the cylinder will be higher than its original position.
(D)	Incorrect. The relative sizes of the reactant and product molecules are not relevant because gas behavior is modeled on the gas particles having negligible size compared to the size of interparticle distances within the gas. What is relevant is that, as the balanced equation indicates, more moles of gas (18) are produced than the number of moles of gas consumed (15) as the reaction proceeds. Therefore, when the reaction is complete and the temperature and pressure are returned to their original values, the volume of gases in the cylinder must be greater (V is proportional to n when both T and P are held constant). Thus, the position of the piston in the cylinder will be higher than its original position.

Question 26

Skill	Learning Objective	Topic
6.E	3.1.A	Intermolecular and Interparticle Forces

(A)	**Correct**. The chlorine atom has fewer occupied shells than the iodine atom. The chloroacetic acid molecule thus has a smaller, less polarizable electron cloud than the iodoacetic acid molecule, so chloroacetic acid has weaker London dispersion forces than iodoacetic acid. The weaker the intermolecular forces, the lower the boiling point.
(B)	Incorrect. The chloroacetic acid molecule and the iodoacetic acid molecule have the same structure and similar dipole moments. The chloroacetic acid molecule has a smaller, less polarizable electron cloud than the iodoacetic acid molecule, so chloroacetic acid has weaker London dispersion forces and a lower boiling point than iodoacetic acid.
(C)	Incorrect. Chloroacetic acid has the lower boiling point. The chloroacetic acid molecule has a smaller, less polarizable electron cloud than the iodoacetic acid molecule, so chloroacetic acid has weaker London dispersion forces than iodoacetic acid. The weaker the intermolecular forces, the lower the boiling point.
(D)	Incorrect. Chloroacetic acid has the lower boiling point. Chloroacetic acid has weaker London dispersion forces than iodoacetic acid because the chloroacetic acid molecule has a smaller, less polarizable electron cloud than the iodoacetic acid molecule. The weaker the intermolecular forces, the lower the boiling point.

Question 27

Skill	Learning Objective	Topic
4.A	8.3.A	Weak Acid and Base Equilibria

(A)	Incorrect. When the acids are at equal concentrations, the percent ionization of chloroacetic acid is less than that of fluoroacetic acid. Fluoroacetic acid has a larger K_a than chloroacetic acid does, so it is a stronger acid and has a larger percent ionization in aqueous solution. The equilibrium-constant expressions for the acids still apply when the two acids are combined, so the percent ionization of fluoroacetic acid will still be greater than that of chloroacetic acid in a mixture of equal concentrations of the acids.
(B)	**Correct**. Fluoroacetic acid has a larger K_a than chloroacetic acid does, so it is a stronger acid and at equal concentrations has a larger percent ionization in aqueous solution. The equilibrium-constant expressions for the acids still apply when the two acids are combined, so the percent ionization of fluoroacetic acid will still be greater than that of chloroacetic acid in a mixture of equal concentrations of the acids.
(C)	Incorrect. The concentrations of the acids are equal, and the concentration is not needed to compare percent ionization. Fluoroacetic acid has a larger K_a than chloroacetic acid does, so it is a stronger acid and at equal concentrations has a larger percent ionization in aqueous solution. The equilibrium-constant expressions for the acids still apply when the two acids are combined, so the percent ionization of fluoroacetic acid will still be greater than that of chloroacetic acid in a mixture of equal concentrations of the acids.
(D)	Incorrect. The pH is not needed to compare percent ionization. Fluoroacetic acid has a larger K_a than chloroacetic acid does, so it is a stronger acid and at equal concentrations has a larger percent ionization in aqueous solution. The equilibrium-constant expressions for the acids still apply when the two acids are combined, so the percent ionization of fluoroacetic acid will still be greater than that of chloroacetic acid in a mixture of equal concentrations of the acids.

Question 28

Skill	Learning Objective	Topic
4.A	4.6.A	Introduction to Titration

(A)	Incorrect. At the equivalence point, the number of moles of each monoprotic acid used is equal to the number of moles of NaOH(*aq*) added. Since equimolar amounts of the acids are used and the same NaOH(*aq*) solution is used for all four titrations, the volume of NaOH(*aq*) needed to reach the equivalence point is the same for all four titrations.
(B)	Incorrect. At the equivalence point, the number of moles of each monoprotic acid used is equal to the number of moles of NaOH(*aq*) added. Since equimolar amounts of the acids are used and the same NaOH(*aq*) solution is used for all four titrations, the volume of NaOH(*aq*) needed to reach the equivalence point is the same for all four titrations.
(C)	**Correct**. At the equivalence point, the number of moles of each monoprotic acid used is equal to the number of moles of NaOH(*aq*) added. Since equimolar amounts of the acids are used and the same NaOH(*aq*) solution is used for all four titrations, the volume of NaOH(*aq*) needed to reach the equivalence point is the same for all four titrations.
(D)	Incorrect. When a weak acid is titrated with a strong base, the titration does have an equivalence point. At the equivalence point, the number of moles of each monoprotic acid used is equal to the number of moles of NaOH(*aq*) added. Since equimolar amounts of the acids are used and the same NaOH(*aq*) solution is used for all four titrations, the volume of NaOH(*aq*) needed to reach the equivalence point is the same for all four titrations.

Question 29

Skill	Learning Objective	Topic
5.F	8.1.A	Introduction to Acids and Bases

(A)	Incorrect. $K_w = [H^+][OH^-]$. Since one H_2O molecule ionizes to form one H^+ ion and one OH^- ion, $[H^+] = [OH^-]$, and $[H^+] = \sqrt{K_w} = \sqrt{3.0\times10^{-14}}$. The value $\sqrt{3.0\times10^{-14}}$ can be estimated to be between 1×10^{-7} and 2×10^{-7}. Since $pH = -\log[H^+]$, the pH must be slightly less than 7 (6.8).
(B)	**Correct**. $K_w = [H^+][OH^-]$. Since one H_2O molecule ionizes to form one H^+ ion and one OH^- ion, $[H^+] = [OH^-]$, and $[H^+] = \sqrt{K_w} = \sqrt{3.0\times10^{-14}}$. The value $\sqrt{3.0\times10^{-14}}$ can be estimated to be between 1×10^{-7} and 2×10^{-7} and the log between –7 and –6. Since $pH = -\log[H^+]$, the pH must be slightly less than 7 (6.8). Qualitatively, since K_w at 40°C is greater than K_w at 25°C (1×10^{-14}), this means that water ionizes more at the higher temperature, so the concentration of H^+ must be higher at the higher temperature, so the pH must be lower than 7.
(C)	Incorrect. The pH of pure water is 7.0 at 25°C, but since the ionization constant varies with temperature, the pH of pure water also varies with temperature. $K_w = [H^+][OH^-]$. Since one H_2O molecule ionizes to form one H^+ ion and one OH^- ion, $[H^+] = [OH^-]$, and $[H^+] = \sqrt{K_w} = \sqrt{3.0\times10^{-14}}$. The value $\sqrt{3.0\times10^{-14}}$ can be estimated to be between 1×10^{-7} and 2×10^{-7}. Since $pH = -\log[H^+]$, the pH must be slightly less than 7 (6.8).
(D)	Incorrect. $K_w = [H^+][OH^-]$. Since one H_2O molecule ionizes to form one H^+ ion and one OH^- ion, $[H^+] = [OH^-]$, and $[H^+] = \sqrt{K_w} = \sqrt{3.0\times10^{-14}}$. The value $\sqrt{3.0\times10^{-14}}$ can be estimated to be between 1×10^{-7} and 2×10^{-7}. Since $pH = -\log[H^+]$, the pH must be slightly less than 7 (6.8).

Question 30

Skill	Learning Objective	Topic
4.A	6.3.A	Heat Transfer and Thermal Equilibrium

(A)	Incorrect. The average kinetic energy of a sample of gas particles is greater at a higher temperature. When the two samples are combined, the particles of the two different gases collide, and the net effect is that kinetic energy is transferred from the particles at the higher temperature to the particles at the lower temperature until the particles of the two gases have the same average kinetic energy and are at the same temperature. The Xe atoms started at the higher temperature, so the average kinetic energy of the Xe atoms decreases when the two gases are combined. Since $KE = \frac{1}{2}mv^2$ (where v is speed), if the average kinetic energy decreases then the average speed must also decrease.
(B)	Incorrect. The average kinetic energy of a sample of gas particles is greater at a higher temperature. When the two samples are combined, the particles of the two different gases collide, and the net effect is that kinetic energy is transferred from the particles at the higher temperature to the particles at the lower temperature until the particles of the two gases have the same average kinetic energy and are at the same temperature. The Xe atoms started at the higher temperature, so the average kinetic energy of the Xe atoms decreases when the two gases are combined. Since $KE = \frac{1}{2}mv^2$ (where v is speed), if the average kinetic energy decreases then the average speed must also decrease.
(C)	Incorrect. The average kinetic energy of a sample of gas particles is greater at a higher temperature. When the two samples are combined, the particles of the two different gases collide, and the net effect is that kinetic energy is transferred from the particles at the higher temperature to the particles at the lower temperature until the particles of the two gases have the same average kinetic energy and are at the same temperature. The Xe atoms started at the higher temperature, so the average kinetic energy of the Xe atoms decreases when the two gases are combined. Since $KE = \frac{1}{2}mv^2$ (where v is speed), if the average kinetic energy decreases then the average speed must also decrease.
(D)	**Correct**. The average kinetic energy of a sample of gas particles is greater at a higher temperature. When the two samples are combined, the particles of the two different gases collide, and the net effect is that kinetic energy is transferred from the particles at the higher temperature to the particles at the lower temperature until the particles of the two gases have the same average kinetic energy and are at the same temperature. The Xe atoms started at the higher temperature, so the average kinetic energy of the Xe atoms decreases when the two gases are combined. Since $KE = \frac{1}{2}mv^2$ (where v is speed), if the average kinetic energy decreases then the average speed must also decrease.

Question 31

Skill	Learning Objective	Topic
4.C	1.8.A	Valence Electrons and Ionic Compounds

(A)	Incorrect. Ionization energy is the energy needed to remove an electron from an atom. When Na and Mg react with water, they lose electrons to become positive ions. The first ionization energy of Na is less than that of Mg, so Na loses an electron more easily than Mg does.
(B)	Incorrect. Ionization energy is the energy needed to remove an electron from an atom. When Na and Mg react with water, they lose electrons to become positive ions. The first ionization energy of Na is less than that of Mg, so Na loses an electron more easily than Mg does.
(C)	Incorrect. Ionization energy is the energy needed to remove an electron from an atom. When Na and Mg react with water, they lose electrons to become positive ions. The first ionization energy of Na is less than that of Mg, so Na loses an electron more easily than Mg does.
(D)	**Correct**. Ionization energy is the energy needed to remove an electron from an atom. When Na and Mg react with water, they lose electrons to become positive ions. The first ionization energy of Na is less than that of Mg, so Na loses an electron more easily than Mg does.

Question 32

Skill	Learning Objective	Topic
5.F	8.1.A	Introduction to Acids and Bases

(A)	Incorrect. The pH scale is logarithmic. For the pH to increase by 1, the concentration of the acid must decrease by a factor of 10. Therefore, the 30.0 mL sample must have been diluted to form a 300. mL sample, which is done by adding approximately 270. mL of water.
(B)	Incorrect. The pH scale is logarithmic. For the pH to increase by 1, the concentration of the acid must decrease by a factor of 10. Therefore, the 30.0 mL sample must have been diluted to form a 300. mL sample, which is done by adding approximately 270. mL of water.
(C)	**Correct**. The pH scale is logarithmic. For the pH to increase by 1, the concentration of the acid must decrease by a factor of 10. Therefore, the 30.0 mL sample must have been diluted to form a 300. mL sample, which is done by adding approximately 270. mL of water.
(D)	Incorrect. The pH scale is logarithmic. For the pH to increase by 1, the concentration of the acid must decrease by a factor of 10. Therefore, the 30.0 mL sample must have been diluted to form a 300. mL sample, which is done by adding approximately 270. mL of water.

Question 33

Skill	**Learning Objective**	**Topic**
5.B	9.3.A	Gibbs Free Energy and Thermodynamic Favorability

(A)	Incorrect. When the equilibrium constant is greater than 1.0, $\Delta G°$ is less than 0 (the reaction is thermodynamically favorable), and when the equilibrium constant is less than 1.0, $\Delta G°$ is greater than 0 (the reaction is not thermodynamically favorable). Since $\Delta G° = \Delta H° - T\Delta S°$, $\Delta H° < 0$ and $\Delta S° < 0$ results in a negative $\Delta G°$ at low temperatures and a positive $\Delta G°$ at high temperatures.
(B)	Incorrect. When the equilibrium constant is greater than 1.0, $\Delta G°$ is less than 0 (the reaction is thermodynamically favorable), and when the equilibrium constant is less than 1.0, $\Delta G°$ is greater than 0 (the reaction is not thermodynamically favorable). Since $\Delta G° = \Delta H° - T\Delta S°$, $\Delta H° < 0$ and $\Delta S° < 0$ results in a negative $\Delta G°$ at low temperatures and a positive $\Delta G°$ at high temperatures.
(C)	Incorrect. When the equilibrium constant is greater than 1.0, $\Delta G°$ is less than 0 (the reaction is thermodynamically favorable), and when the equilibrium constant is less than 1.0, $\Delta G°$ is greater than 0 (the reaction is not thermodynamically favorable). Since $\Delta G° = \Delta H° - T\Delta S°$, $\Delta H° < 0$ and $\Delta S° < 0$ results in a negative $\Delta G°$ at low temperatures and a positive $\Delta G°$ at high temperatures.
(D)	**Correct**. When the equilibrium constant is greater than 1.0, $\Delta G°$ is less than 0 (the reaction is thermodynamically favorable), and when the equilibrium constant is less than 1.0, $\Delta G°$ is greater than 0 (the reaction is not thermodynamically favorable). Since $\Delta G° = \Delta H° - T\Delta S°$, $\Delta H° < 0$, and $\Delta S° < 0$ results in a negative $\Delta G°$ at low temperatures and a positive $\Delta G°$ at high temperatures.

Question 34

Skill	Learning Objective	Topic
6.F	7.11.A	Introduction to Solubility Equilibria

(A)	Incorrect. The concentration of ions in a saturated solution of an ionic solid at a given temperature is constant. As water evaporates from the solution, enough of the solute precipitates to keep the concentration of the ions in solution constant.
(B)	Incorrect. The concentration of ions in a saturated solution of an ionic solid at a given temperature is constant. As water evaporates from the solution, enough of the solute precipitates to keep the concentration of the ions in solution constant.
(C)	Incorrect. The concentration of ions in a saturated solution of an ionic solid at a given temperature is constant. As water evaporates from the solution, enough of the solute precipitates to keep the concentration of the ions in solution constant.
(D)	**Correct**. The concentration of ions in a saturated solution of an ionic solid at a given temperature is constant. As water evaporates from the solution, enough of the solute precipitates to keep the concentration of the ions in solution constant.

Question 35

Skill	Learning Objective	Topic
5.E	4.2.A	Net Ionic Equations

(A)	Incorrect. Since the question asks for the species that react and the species that are produced, the equation should be written in net ionic form. The products of the reaction are $Ca^{2+}(aq)$, $CO_2(g)$, and $H_2O(l)$.
(B)	**Correct**. Since the question asks for the species that react and the species that are produced, the equation should be written in net ionic form. The products of the reaction are $Ca^{2+}(aq)$, $CO_2(g)$, and $H_2O(l)$.
(C)	Incorrect. Since the question asks for the species that react and the species that are produced, the equation should be written in net ionic form. The products of the reaction are $Ca^{2+}(aq)$, $CO_2(g)$, and $H_2O(l)$.
(D)	Incorrect. Since the question asks for the species that react and the species that are produced, the equation should be written in net ionic form. The products of the reaction are $Ca^{2+}(aq)$, $CO_2(g)$, and $H_2O(l)$. $Cl^-(aq)$ is not included because it is a spectator ion.

Question 36

Skill	Learning Objective	Topic
5.F	1.4.A	Composition of Mixtures

(A)	Incorrect. The difference in pressure is $0.870\text{ atm} - 0.800\text{ atm} = 0.070\text{ atm}$. According to the graph, this pressure corresponds to a mass of $CaCO_3(s)$ of 0.145 g. The mass of eggshell used was 0.200 g. The mass percent of $CaCO_3(s)$ in the eggshell was thus approximately $\frac{0.145\text{ g}}{0.200\text{ g}} \times 100 = 73\%$.
(B)	Incorrect. The difference in pressure is $0.870\text{ atm} - 0.800\text{ atm} = 0.070\text{ atm}$. According to the graph, this pressure corresponds to a mass of $CaCO_3(s)$ of 0.145 g. The mass of eggshell used was 0.200 g. The mass percent of $CaCO_3(s)$ in the eggshell was thus approximately $\frac{0.145\text{ g}}{0.200\text{ g}} \times 100 = 73\%$.
(C)	Incorrect. The difference in pressure is $0.870\text{ atm} - 0.800\text{ atm} = 0.070\text{ atm}$. According to the graph, this pressure corresponds to a mass of $CaCO_3(s)$ of 0.145 g. The mass of eggshell used was 0.200 g. The mass percent of $CaCO_3(s)$ in the eggshell was thus approximately $\frac{0.145\text{ g}}{0.200\text{ g}} \times 100 = 73\%$.
(D)	**Correct**. The difference in pressure is $0.870\text{ atm} - 0.800\text{ atm} = 0.070\text{ atm}$. According to the graph, this pressure corresponds to a mass of $CaCO_3(s)$ of 0.145 g. The mass of eggshell used was 0.200 g. The mass percent of $CaCO_3(s)$ in the eggshell was thus approximately $\frac{0.145\text{ g}}{0.200\text{ g}} \times 100 = 73\%$.

Question 37

Skill	Learning Objective	Topic
5.F	3.7.A	Solutions and Mixtures

(A)	Incorrect. According to the graph, 0.095 atm of gas corresponds to approximately 0.20 g of $CaCO_3$. Since the molar mass of $CaCO_3$ is 100. g/mol, this corresponds to 0.0020 mol of $CaCO_3$. Each mole of $CaCO_3$ requires two moles of H^+ ions in the reaction, so 0.0040 mol of acid is needed. $\frac{0.0040 \text{ mol}}{4.0 \text{ mL}} = \frac{x \text{ mol}}{1000 \text{ mL}}$, so $x = 1.0$, and the concentration of HCl(*aq*) was 1.0 *M*.
(B)	Incorrect. According to the graph, 0.095 atm of gas corresponds to approximately 0.20 g of $CaCO_3$. Since the molar mass of $CaCO_3$ is 100. g/mol, this corresponds to 0.0020 mol of $CaCO_3$. Each mole of $CaCO_3$ requires two moles of H^+ ions in the reaction, so 0.0040 mol of acid is needed. $\frac{0.0040 \text{ mol}}{4.0 \text{ mL}} = \frac{x \text{ mol}}{1000 \text{ mL}}$, so $x = 1.0$, and the concentration of HCl(*aq*) was 1.0 *M*.
(C)	Incorrect. According to the graph, 0.095 atm of gas corresponds to approximately 0.20 g of $CaCO_3$. Since the molar mass of $CaCO_3$ is 100. g/mol, this corresponds to 0.0020 mol of $CaCO_3$. Each mole of $CaCO_3$ requires two moles of H^+ ions in the reaction, so 0.0040 mol of acid is needed. $\frac{0.0040 \text{ mol}}{4.0 \text{ mL}} = \frac{x \text{ mol}}{1000 \text{ mL}}$, so $x = 1.0$, and the concentration of HCl(*aq*) was 1.0 *M*.
(D)	**Correct**. According to the graph, 0.095 atm of gas corresponds to approximately 0.20 g of $CaCO_3$. Since the molar mass of $CaCO_3$ is 100. g/mol, this corresponds to 0.0020 mol of $CaCO_3$. Each mole of $CaCO_3$ requires two moles of H^+ ions in the reaction, so 0.0040 mol of acid is needed. $\frac{0.0040 \text{ mol}}{4.0 \text{ mL}} = \frac{x \text{ mol}}{1000 \text{ mL}}$, so $x = 1.0$, and the concentration of HCl(*aq*) was 1.0 *M*.

Question 38

Skill		Learning Objective	Topic
1.B		5.1.A	Reaction Rates
(A)	Incorrect. Using a weak acid instead of a strong acid would not increase the rate of the reaction. Increasing the surface area of the reactant increases the rate of the reaction, because more of the solid $CaCO_3$ is in contact with the H^+ ions in solution.		
(B)	Incorrect. Reaction rates typically increase when the temperature is increased, not when it is decreased. Increasing the surface area of the reactant increases the rate of the reaction, because more of the solid $CaCO_3$ is in contact with the H^+ ions in solution.		
(C)	Incorrect. Reducing the volume of the reaction vessel would not increase the rate of the reaction—it would not increase concentrations in an aqueous solution. Increasing the surface area of the reactant increases the rate of the reaction, because more of the solid $CaCO_3$ is in contact with the H^+ ions in solution.		
(D)	**Correct**. Increasing the surface area of the reactant increases the rate of the reaction, because more of the solid $CaCO_3$ is in contact with the H^+ ions in solution.		

Question 39

Skill		Learning Objective	Topic
5.E		8.3.A	Weak Acid and Base Equilibria
(A)	Incorrect. The Na^+ ion does not react with water as shown in the equation. $NH_4^+(aq)$ partially hydrolyzes (reacts with water) to form $NH_3(aq)$ and $H_3O^+(aq)$. Since $H_3O^+(aq)$ is a product, the resulting solution is slightly acidic.		
(B)	Incorrect. The solution formed in this reaction is slightly basic (OH^- ions are formed). $NH_4^+(aq)$ partially hydrolyzes (reacts with water) to form $NH_3(aq)$ and $H_3O^+(aq)$. Since $H_3O^+(aq)$ is a product, the resulting solution is slightly acidic.		
(C)	**Correct**. $NH_4^+(aq)$ partially hydrolyzes (reacts with water) to form $NH_3(aq)$ and $H_3O^+(aq)$. Since $H_3O^+(aq)$ is a product, the resulting solution is slightly acidic.		
(D)	Incorrect. The Cl^- ion does not react with water as shown in the equation. $NH_4^+(aq)$ partially hydrolyzes (reacts with water) to form $NH_3(aq)$ and $H_3O^+(aq)$. Since $H_3O^+(aq)$ is a product, the resulting solution is slightly acidic.		

Question 40

Skill		Learning Objective	Topic
6.E		9.4.A	Thermodynamic and Kinetic Control
(A)	Incorrect. The value of $\Delta G°$ does not indicate anything about the rate of a reaction, just its thermodynamic favorability. Reactions with high activation energies are very slow. Energy is needed to break bonds in reactant molecules, and diamond is a covalent network solid with strong bonds in four different directions.		
(B)	Incorrect. The change in entropy does not affect the rate of the reaction. Reactions with high activation energies are very slow. Energy is needed to break bonds in reactant molecules, and diamond is a covalent network solid with strong bonds in four different directions.		
(C)	**Correct**. Reactions with high activation energies are very slow. Energy is needed to break bonds in reactant molecules, and diamond is a covalent network solid with strong bonds in four different directions.		
(D)	Incorrect. The value of $\Delta G°$ is negative, so the reaction is thermodynamically favorable. Reactions with high activation energies are very slow. Energy is needed to break bonds in reactant molecules, and diamond is a covalent network solid with strong bonds in four different directions.		

Question 41

Skill		Learning Objective	Topic
4.A		8.5.A	Acid-Base Titrations
(A)	Incorrect. At the equivalence point, the number of moles of $OH^-(aq)$ added is equal to the initial number of moles of $C_9H_8O_4(aq)$, and the reaction shown has gone essentially to completion. Therefore, the concentration of $C_9H_7O_4^-(aq)$ is much greater than that of $C_9H_8O_4(aq)$.		
(B)	**Correct**. At the equivalence point, the number of moles of $OH^-(aq)$ added is equal to the initial number of moles of $C_9H_8O_4(aq)$, and the reaction shown has gone essentially to completion. Therefore, the concentration of $C_9H_7O_4^-(aq)$ is much greater than that of $C_9H_8O_4(aq)$.		
(C)	Incorrect. At the equivalence point, the number of moles of $OH^-(aq)$ added is equal to the initial number of moles of $C_9H_8O_4(aq)$, and the reaction shown has gone essentially to completion. Therefore, the concentration of $C_9H_7O_4^-(aq)$ is much greater than that of $C_9H_8O_4(aq)$.		
(D)	Incorrect. At the equivalence point, the number of moles of $OH^-(aq)$ added is equal to the initial number of moles of $C_9H_8O_4(aq)$, and the reaction shown has gone essentially to completion. Therefore, the concentration of $C_9H_7O_4^-(aq)$ is much greater than that of $C_9H_8O_4(aq)$.		

Question 42

Skill		Learning Objective	Topic
1.A		2.7.A	VSEPR and Hybridization
(A)	Incorrect. The oxygen atom in the H−O−C bond has two lone pairs of electrons, so the geometry of the electron domains around the oxygen atom is roughly tetrahedral. The bond angle is thus close to 109°.		
(B)	Incorrect. The oxygen atom in the H−O−C bond has two lone pairs of electrons, so the geometry of the electron domains around the oxygen atom is roughly tetrahedral. The bond angle is thus close to 109°.		
(C)	**Correct**. The oxygen atom in the H−O−C bond has two lone pairs of electrons, so the geometry of the electron domains around the oxygen atom is roughly tetrahedral. The bond angle is thus close to 109°.		
(D)	Incorrect. The oxygen atom in the H−O−C bond has two lone pairs of electrons, so the geometry of the electron domains around the oxygen atom is roughly tetrahedral. The bond angle is thus close to 109°.		

Question 43

Skill		Learning Objective	Topic
1.A		2.7.A	VSEPR and Hybridization
(A)	Incorrect. The leftmost carbon atom is bonded to four atoms and it does not have any nonbonding pairs of electrons, so it has four electron domains. The geometry of the electron domains around the leftmost carbon atom is thus roughly tetrahedral.		
(B)	**Correct**. The carbon atom bonded to two oxygen atoms and another carbon atom does not have any nonbonding pairs of electrons, thus the central carbon atom has three electron domains. According to VSEPR theory, all four atoms are in the same plane (sp^2 hybridization).		
(C)	Incorrect. The leftmost carbon atom is bonded to four atoms and it does not have any nonbonding pairs of electrons on it, so it has four electron domains. The geometry of the electron domains around the leftmost carbon atom is thus roughly tetrahedral and the N−C−C bond angle is roughly 109°.		
(D)	Incorrect. The nitrogen atom is bonded to four atoms and it does not have any nonbonding pairs of electrons on it, so it has four electron domains. The geometry of the electron domains around the nitrogen atom is thus roughly tetrahedral.		

Question 44

Skill		Learning Objective	Topic
1.A		3.2.A	Properties of Solids
(A)	**Correct**. The sodium ion and the glycinate ion form the ionic compound sodium glycinate.		
(B)	Incorrect. The sodium ion and the glycinate ion form the ionic compound sodium glycinate, which, like all sodium salts, is soluble in water.		
(C)	Incorrect. The sodium ion and the glycinate ion form the ionic compound sodium glycinate, which does not evaporate easily.		
(D)	Incorrect. The sodium ion and the glycinate ion form the ionic compound sodium glycinate. The glycinate ion is formed through the loss of a proton (H^+) and would not lose another proton in aqueous solution to form an acidic solution.		

Question 45

Skill		Learning Objective	Topic
1.A		2.1.A	Types of Chemical Bonds
(A)	Incorrect. Polar covalent bonds are the <u>intra</u>molecular forces within a carbon tetrachloride molecule. Carbon tetrachloride molecules have equivalent bonds that are symmetrically arranged around the carbon atom; thus, the bond dipoles cancel and the molecules are nonpolar. The attractions between molecules are London dispersion forces, which result from temporary dipoles.		
(B)	Incorrect. Polar (not nonpolar) covalent bonds are the <u>intra</u>molecular forces within a carbon tetrachloride molecule. Carbon tetrachloride molecules have equivalent bonds that are symmetrically arranged around the carbon atom; thus, the bond dipoles cancel and the molecules are nonpolar. The attractions between molecules are London dispersion forces, which result from temporary dipoles.		
(C)	**Correct**. Carbon tetrachloride molecules have equivalent bonds that are symmetrically arranged around the carbon atom; thus, the bond dipoles cancel and the molecules are nonpolar. The attractions between molecules are London dispersion forces, which result from temporary dipoles.		
(D)	Incorrect. Carbon tetrachloride molecules have equivalent bonds that are symmetrically arranged around the carbon atom; thus, the bond dipoles cancel and the molecules are nonpolar. The attractions between molecules are London dispersion forces, which result from temporary dipoles.		

Question 46

Skill	Learning Objective	Topic
2.C	6.4.A	Heat Capacity and Calorimetry

(A)	Incorrect. The mass of the water is also needed.
(B)	Incorrect. The mass of the KCl(*s*) is also needed.
(C)	**Correct**. The formula $q = mc\Delta T$ is the formula used to determine the amount of heat (q) released or absorbed when KCl(*s*) is dissolved in water. The experimental procedure is to dissolve a known amount of KCl(*s*) in a known mass of water and to measure the temperature before and after the dissolution. The enthalpy change for the dissolution of one mole of KCl(*s*) can then be calculated.
(D)	Incorrect. The atmospheric pressure is not needed, as would be the case if the vapor pressure of the water was needed.

Question 47

Skill	Learning Objective	Topic
5.F	7.10.A	Reaction Quotient and Le Châtelier's Principle

(A)	**Correct**. At these initial concentrations, $Q = \frac{[XY]^2}{[X_2][Y_2]} = \frac{(0.20)^2}{(0.40)(0.40)} = \frac{0.040}{0.16} = 0.25$. Since $Q < K_c$, the system will shift to the right and more product will form.
(B)	Incorrect. At these initial concentrations, $Q = \frac{[XY]^2}{[X_2][Y_2]} = \frac{(0.90)(0.90)}{(0.30)(0.30)} = \frac{(3)(3)}{(1)(1)} = 9.0$. Since $Q > K_c$, the system will shift to the left and more reactants will form.
(C)	Incorrect. At these initial concentrations, $Q = \frac{[XY]^2}{[X_2][Y_2]} = \frac{(0.30)(0.30)}{(0.15)(0.15)} = \frac{(2)(2)}{(1)(1)} = 4.0$. Since $Q > K_c$, the system will shift to the left and more reactants will form.
(D)	Incorrect. At these initial concentrations, $Q = \frac{[XY]^2}{[X_2][Y_2]} = \frac{(0.20)(0.20)}{(0.10)(0.10)} = \frac{(2)(2)}{(1)(1)} = 4.0$. Since $Q > K_c$, the system will shift to the left and more reactants will form.

Question 48

Skill	Learning Objective	Topic
6.E	3.1.A	Intermolecular Forces

(A)	Incorrect. The bond dipoles cancel in the *trans*-isomer because they are equal and pointed in opposite directions. The bond dipoles in the *cis*-isomer do not cancel, so the molecules have a net dipole moment, which means that the *cis*-isomer has dipole-dipole forces in addition to London dispersion forces. Since the *trans*-isomer has only London dispersion forces (which are equal in strength to the London dispersion forces in the *cis*-isomer), it is easier for the molecules of the *trans*-isomer to escape the surface of the liquid; thus, it has a higher equilibrium vapor pressure.
(B)	Incorrect. The bond dipoles cancel in the *trans*-isomer because they are equal and pointed in opposite directions. The bond dipoles in the *cis*-isomer do not cancel, so the molecules have a net dipole moment, which means that the *cis*-isomer has dipole-dipole forces in addition to London dispersion forces. Since the *trans*-isomer has only London dispersion forces (which are equal in strength to the London dispersion forces in the *cis*-isomer), it is easier for the molecules of the *trans*-isomer to escape the surface of the liquid; thus, it has a higher equilibrium vapor pressure.
(C)	Incorrect. The bond dipoles cancel in the *trans*-isomer because they are equal and pointed in opposite directions. The bond dipoles in the *cis*-isomer do not cancel, so the molecules have a net dipole moment, which means that the *cis*-isomer has dipole-dipole forces in addition to London dispersion forces. Since the *trans*-isomer has only London dispersion forces (which are equal in strength to the London dispersion forces in the *cis*-isomer), it is easier for the molecules of the *trans*-isomer to escape the surface of the liquid; thus, it has a higher equilibrium vapor pressure.
(D)	**Correct**. The bond dipoles cancel in the *trans*-isomer because they are equal and pointed in opposite directions. The bond dipoles in the *cis*-isomer do not cancel, so the molecules have a net dipole moment, which means that the *cis*-isomer has dipole-dipole forces in addition to London dispersion forces. Since the *trans*-isomer has only London dispersion forces (which are equal in strength to the London dispersion forces in the *cis*-isomer), it is easier for the molecules of the *trans*-isomer to escape the surface of the liquid; thus, it has a higher equilibrium vapor pressure.

Question 49

Skill	Learning Objective	Topic
5.F	3.2.A	Common-Ion Effect

(A)	Incorrect. $K_{sp} = [Ca^{2+}][F^-]^2$, so $4.0\times10^{-11} = [Ca^{2+}][4.0\times10^{-5}]^2$, and $[Ca^{2+}] = \frac{4.0\times10^{-11}}{16\times10^{-10}} = \frac{4.0\times10^{-11}}{1.6\times10^{-9}} = 2.5\times10^{-11-(-9)} = 0.025\ M$.
(B)	**Correct**. $K_{sp} = [Ca^{2+}][F^-]^2$, so $4.0\times10^{-11} = [Ca^{2+}][4.0\times10^{-5}]^2$, and $[Ca^{2+}] = \frac{4.0\times10^{-11}}{16\times10^{-10}} = \frac{4.0\times10^{-11}}{1.6\times10^{-9}} = 2.5\times10^{-11-(-9)} = 0.025\ M$.
(C)	Incorrect. $K_{sp} = [Ca^{2+}][F^-]^2$, so $4.0\times10^{-11} = [Ca^{2+}][4.0\times10^{-5}]^2$, and $[Ca^{2+}] = \frac{4.0\times10^{-11}}{16\times10^{-10}} = \frac{4.0\times10^{-11}}{1.6\times10^{-9}} = 2.5\times10^{-11-(-9)} = 0.025\ M$.
(D)	Incorrect. $K_{sp} = [Ca^{2+}][F^-]^2$, so $4.0\times10^{-11} = [Ca^{2+}][4.0\times10^{-5}]^2$, and $[Ca^{2+}] = \frac{4.0\times10^{-11}}{16\times10^{-10}} = \frac{4.0\times10^{-11}}{1.6\times10^{-9}} = 2.5\times10^{-11-(-9)} = 0.025\ M$.

Question 50

Skill	Learning Objective	Topic
5.F	7.6.A	Properties of the Equilibrium Constant

(A)	Incorrect. The third equation is the sum of the first equation and the reverse of the second equation. This means that K_{eq} of the third equation is equal to K_{eq} of the first equation multiplied by $\frac{1}{K_{eq}}$ of the second equation, or $(1\times10^{-6})\times\frac{1}{(1\times10^{-32})}=(1\times10^{-6})(1\times10^{32})=1\times10^{26}$. Since K_{eq} is greater than 1, $\Delta G°$ must be negative.
(B)	Incorrect. The third equation is the sum of the first equation and the reverse of the second equation. This means that K_{eq} of the third equation is equal to K_{eq} of the first equation multiplied by $\frac{1}{K_{eq}}$ of the second equation, or $(1\times10^{-6})\times\frac{1}{(1\times10^{-32})}=(1\times10^{-6})(1\times10^{32})=1\times10^{26}$. Since K_{eq} is greater than 1, $\Delta G°$ must be negative.
(C)	Incorrect. The third equation is the sum of the first equation and the reverse of the second equation. This means that K_{eq} of the third equation is equal to K_{eq} of the first equation multiplied by $\frac{1}{K_{eq}}$ of the second equation, or $(1\times10^{-6})\times\frac{1}{(1\times10^{-32})}=(1\times10^{-6})(1\times10^{32})=1\times10^{26}$. Since K_{eq} is greater than 1, $\Delta G°$ must be negative.
(D)	**Correct**. The third equation is the sum of the first equation and the reverse of the second equation. This means that K_{eq} of the third equation is equal to K_{eq} of the first equation multiplied by $\frac{1}{K_{eq}}$ of the second equation, or $(1\times10^{-6})\times\frac{1}{(1\times10^{-32})}=(1\times10^{-6})(1\times10^{32})=1\times10^{26}$. Since K_{eq} is greater than 1, $\Delta G°$ must be negative.