1. This is a reaction involving the decision: Which reactant is the limiting reactant?

   The equation for the reaction is: $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$.

   The initial diagram shows: 1 $CH_4(g)$ and 4 $O_2(g)$.

   After the reaction goes to completion, there will be one $CO_2(g)$, 2 $H_2O(g)$ and 2 excess $O_2(g)$. The only box that show these values is (D).

   The correct answer is (D).

   *[4.3-TRA-1.C], [4.5-SPQ-4.A]**

2. The rate law: $-\frac{d[A]}{dt} = k[A]^2$ is a second order rate law for the reaction:

$$A \xrightarrow{k} \text{Products}$$

   The half-life of such a reaction depends on the starting concentration of A. This half-life may be found by using the integrated rate law as follows:

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0} \qquad \text{when } t = t_{1/2} \qquad [A] = \frac{[A]_0}{2}$$

$$\frac{2}{[A]_0} = kt_{1/2} + \frac{1}{[A]_0}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

   The correct answer is (D).

   *[5.3-TRA-3.C]**

3. Option (A) gives an equation that describes the decay curve of a first order reactant concentration. The natural log of this equation is the integrated first order rate law as shown below:

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = \ln(e^{-kt})$$

$$\ln[A]_t = -kt + \ln[A]_0$$

   Thus, the equation in option (A) predicts a linear plot of versus time for a first order reaction.

   The correct answer is (A).

   *[5.3-TRA-3.C]**

4. The equilibrium constant at the standard state occurs when $\Delta G° = 0 = -RT \ln K$. Thus, to find the temperature at which $K = 1$, solve the equation for: $\Delta G° = 0 = \Delta H° - T\Delta S°$ for T.

$$T = \frac{\Delta H°}{\Delta S°}$$

The correct answer is (B).

*[9.3-ENE-4.C]**

5. The Nernst equation, $E = E° - \frac{RT}{nF} \ln Q$, relates the cell potential, E, to Q, the reaction quotient. Since $Q = \frac{[\text{products}]^i}{[\text{reactants}]^j}$, changing the concentration of a product will change the cell potential.

The correct answer is (C).

*[9.9-ENE-6.C]**

6. A reaction is thermodynamically favorable in the standard state if $\Delta G° = \Delta H° - T\Delta S°$ is negative.

The correct answer is (B).

*[9.3-ENE-4.C]**

7. The particle diagram indicates one small black ion for every three large white ions. Metal cations of a given period are smaller than the nonmetal anions in the same period because the anions have one more complete shell of electrons and more electron-electron repulsions expanding the electron cloud. $AlCl_3$ is consistent with this diagram because Al^{3+} should be much smaller than Cl^-, and the Al/Cl ratio should be 1/3.

The correct answer is (C).

*[2.3-SAP-3.C]**

8. The mass spectrum of element X shows two stable isotopes separated by two mass units in about a 1:19 abundance proportion with the heavier isotope more abundant. This pattern is consistent with the naturally occurring isotopes of indium, option (C) $^{113}In = 4.29\%$; $^{115}In = 95.71\%$.

The correct answer is (C).

*[1.2-SPQ-1.B]**

9. Option (A) is incorrect because the substances need not all have the same molecular formula. They could have molecular formulas that are multiples of the empirical formula. Option (B) is incorrect because the substances need not all have different molecular formulas. They could all be samples of the same molecular compound. Option (C) is correct because by definition, the substances must have the same empirical formula because they all have the same mass ratio of sulfur to fluorine. Option (D) is incorrect because the substances cannot have different empirical formulas because they all have the same mass ratio of sulfur to fluorine.

   The correct answer is (C).

   *[1.3-SPQ-2.A]**

10. The activation energy is the energy that the reactants need to absorb to reach the transition state where reactants would go on to form products. The reactants here start at 30 kJ/mole and need to reach 70 kJ/mole (30 kJ/mole → 70 kJ/mole). Therefore, the reactants need to absorb 40 kJ/mole, so the E_a = +40 kJ/mole.

$$E_a = PE_{\text{transition state}} - PE_{\text{reactants}} = 70 - 30 = 40 \text{ kJ/mol}$$

   The correct answer is (D).

   *[5.1-TRA-3.A]**

*The authors have combined the newly re-articulated AP Chemistry Unit, Topic, as well as the Learning Objective designations into one "UTLO code" shown below. It is important to note that the organizational structure and the designations themselves belong to the College Board, but the combined "UTLO codes" are the creation of the authors for the purpose of providing a short-hand way of identifying the learning objectives for each of our test questions.

How to identify the Unit, Topic, Big Idea, and Learning Objective from the assigned "UTLO codes":