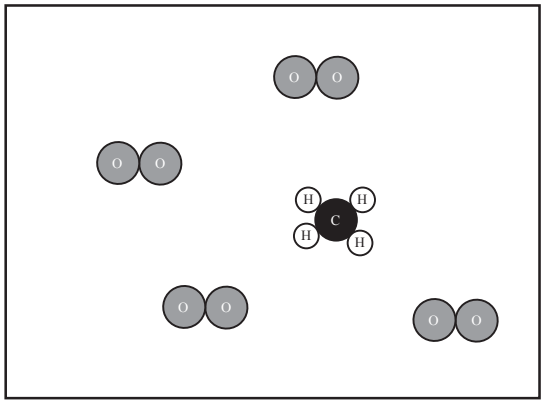
1. The reaction of methane gas with oxygen gas is represented in the balanced chemical equation:

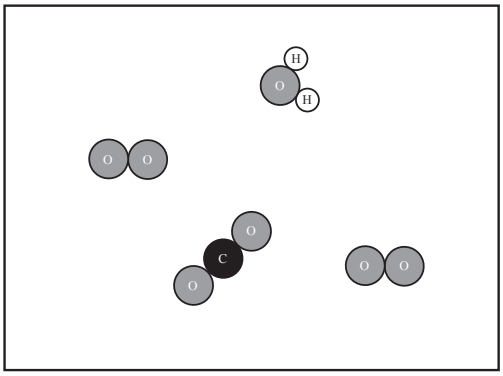
$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$$

In the box below is a particle-level representation of a mixture of methane and oxygen gases.

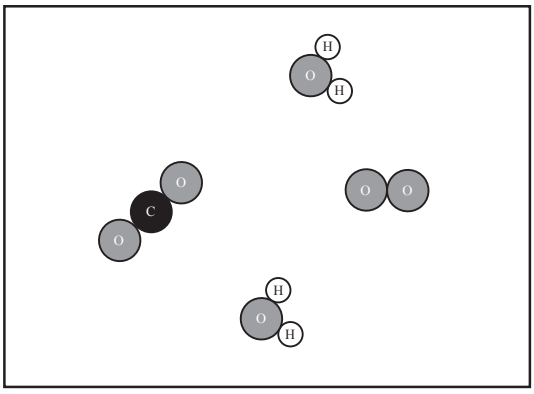


Which of the following diagrams represents a particle level view of the reaction mixture above after reaction has gone to completion?

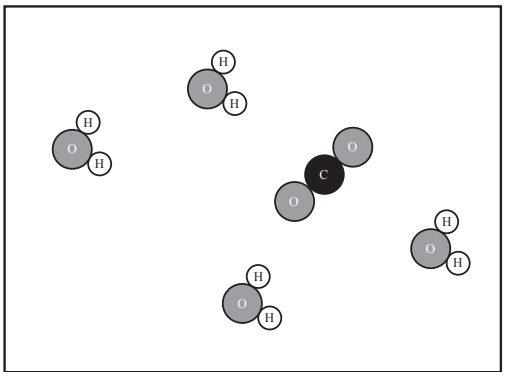
(A)



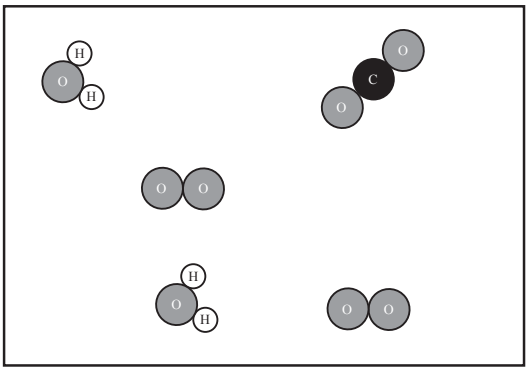
(C)



(B)



(D)



Questions 2–6 use the following options.

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

(B) $\Delta G° = \Delta H° - T\Delta S°$

(C) $E = E° - \frac{RT}{nF} \ln Q$

(D) $\frac{1}{[\mathrm{A}]_t} - \frac{1}{[\mathrm{A}]_0} = -kt$

2. Which of the above equations is useful to determine the half-life of a reaction whose rate law is $\frac{\Delta[\mathrm{A}]}{\Delta t} = k[\mathrm{A}]^2$?

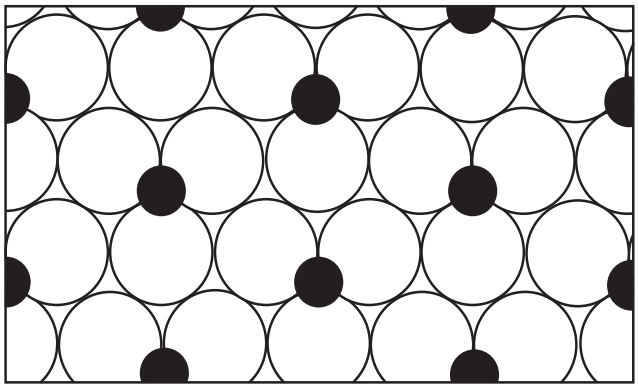
3. Which of the above equations predicts a linear plot of ln[A] versus time for a first order reaction?

4. Which of the above equations is useful to determine the temperature at which the equilibrium constant for a reaction at the standard state is equal to one?

5. Which of the above equations is useful to determine the effect of an added product on the electrochemical cell potential?

6. Which of the above equations is useful to determine a reaction's thermodynamic favorability at the standard state?

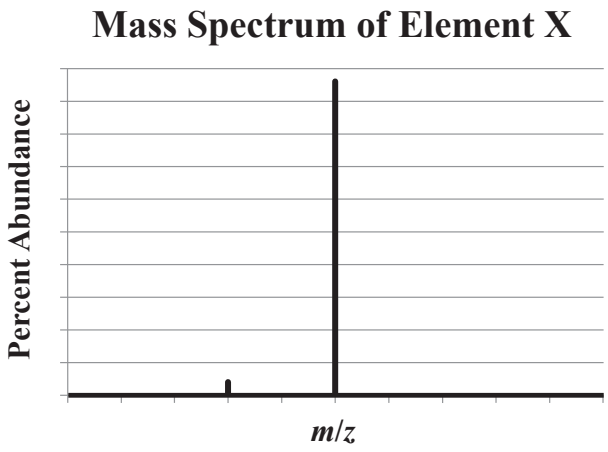
7. The particle-level diagram below represents a two-dimensional projection of a crystalline solid composed of two elements from the third period of the periodic table.



Which of the following ionic compounds could be represented by this particle diagram?

(A) Na_3P
(B) Mg_3P_2
(C) $AlCl_3$
(D) Al_2S_3

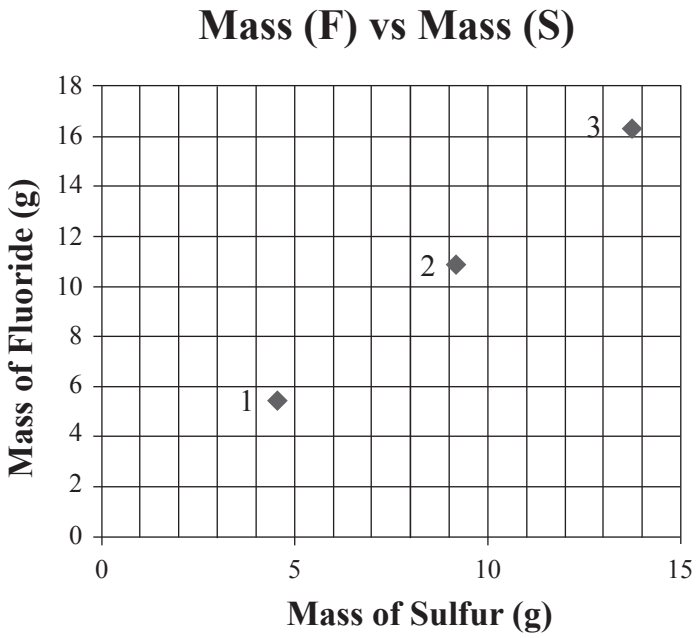
8. The mass spectrum of unknown element X is shown in the graph below:



Which of the following elements would have a mass spectrum that matches the pattern shown by element X?

(A) Boron: $^{10}B = 19.9\%$; $^{11}B = 80.1\%$
(B) Chlorine: $^{35}Cl = 75.78\%$; $^{37}Cl = 24.22\%$
(C) Indium: $^{113}In = 4.29\%$; $^{115}In = 95.71\%$
(D) Europium: $^{151}Eu = 47.8\%$; $^{153}Eu = 52.2\%$

9. Three samples of pure substances of different masses were found to contain only sulfur and fluorine. Analyses of these samples for sulfur and fluorine were carried out and results are shown in the table and in the graph below:

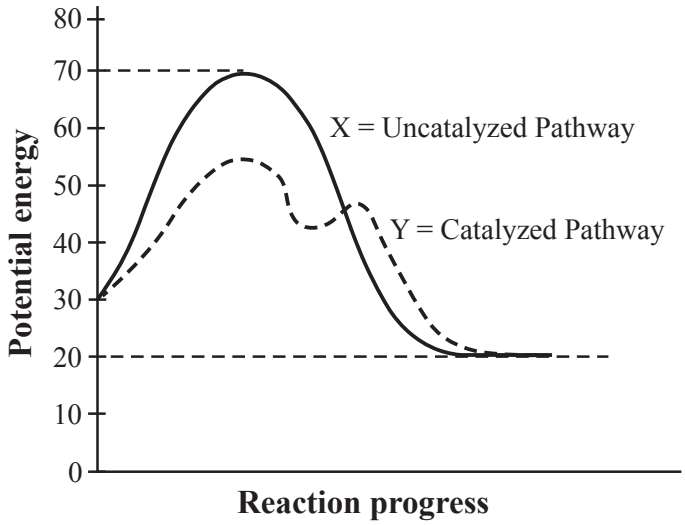


Sample Number	Mass of Sample (g)	Mass of S (g)	Mass of F (g)
1	10.00	4.57	5.43
2	20.00	9.15	10.85
3	30.00	13.73	16.27

Which of the following must be true about the pure substances?

(A) The substances all must have the same molecular formula.
(B) The substances all must have different molecular formulas.
(C) The substances all must have the same empirical formula.
(D) The substances all must have different empirical formulas.

10. The Reaction Energy Diagram below shows the potential energy of a reacting system as a function of reaction progress. Two different reaction pathways are shown. Pathway X is for the uncatalyzed reaction, and pathway Y is for the catalyzed reaction.



The activation energy, E_a (in kJ/mole), for the uncatalyzed reaction is closest to

(A) 70
(B) 60
(C) 50
(D) 40