NTI Day 8 Assignment
Content: ACT Prep 1 – Data Representations
K. Kelly

A student performed an experiment to study the ideal gas law. The ideal gas law is $PV = nRT$, where P denotes pressure, V denotes volume, n denotes the number of moles, R is the gas constant (8.314 J K^{-1} mol^{-1}), and T denotes the temperature.

He performed a chemical reaction involving a metal and an acid, which resulted in the release of a gas. He collected the gas in a container and measured its volume. He repeated this experiment at different temperatures using various amounts of the reactants.

He used the following reaction.

$$Zn + 2HCl \rightarrow ZnCl_2(s) + H_2(g)$$

When hydrochloric acid (HCl) reacts with zinc (Zn) metal, it forms zinc chloride ($ZnCl_2$) and hydrogen gas (H_2).

Experiment 1

The student carried out the reaction several times with varying amounts of Zn. The pressure was kept constant throughout the experiment, the temperature was maintained at 25°C, and the volume of H_2 gas produced was measured for each trial.

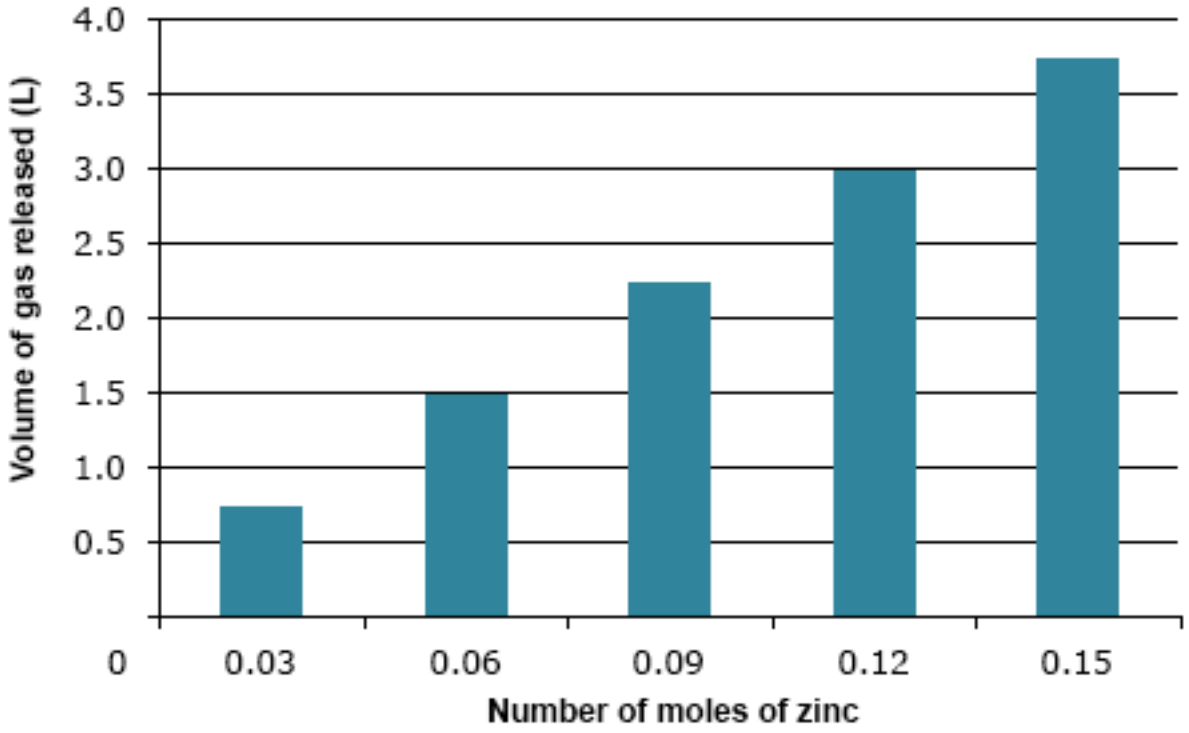

Figure 1

Experiment 2

Experiment 1 was repeated with 0.15 moles of Zn. The pressure was kept constant, a different temperature was used for each trial, and the volume of H_2 gas produced was measured for each trial.

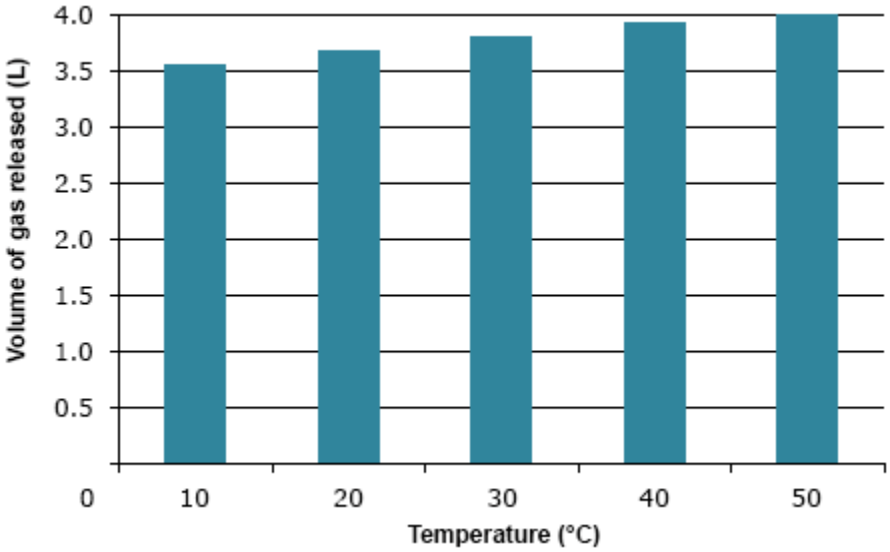

Figure 2

Question 1. If Experiment 2 were carried out with 0.25 moles of Zn, how would the results be different?

- **A.** The volume of gas produced would be lower at each temperature, but as the temperature increases, the volume would increase at the same rate as the original Experiment 2.
- **B.** The volume of gas produced would be greater at each temperature, but as the temperature increases, the volume would increase at the same rate as the original Experiment 2.
- **C.** The volume of gas produced would be the same at each temperature, but as the temperature increases, the volume would increase at a higher rate than the original Experiment 2.
- **D.** The volume of gas produced would be the same at each temperature, but as the temperature increases, the volume would increase at a lower rate than the original Experiment 2.

A dilution is a solution that is less concentrated than the original solution. In a dilution series, the concentration decreases exponentially with each step. A scientist wants to study the transmittance of light through various concentrations of two different solutions. He makes a dilution series of each of two solutes for this purpose. The scientist takes a 1.00 M solution of Solute A and prepares a series of dilutions using water. He then pours a sample of each solution into a different vial. He passes a laser beam through each vial and measures the percentage of light that is transmitted. Table 1 gives his findings.

Table 1

Dilution	Concentration (M)	Transmittance (%)
1:2	0.50	4.0
1:4	0.25	19.8
1:8	0.13	44.5
1:16	0.06	66.7
1:32	0.03	81.7

The scientist repeats the same procedure with a 1.00 M solution of Solute B. Table 2 gives his findings.

Table 2

Dilution	Concentration (M)	Transmittance (%)
1:2	0.50	0.6
1:4	0.25	7.4
1:8	0.13	27.3
1:16	0.06	52.2
1:32	0.03	72.3

Question 2. Suppose that the scientist mixed together the 0.50 M and 0.06 M solutions of Solute A, and then divided the resulting solution equally between the two vials. Assuming the two original solutions had the same volume, what would most likely be the transmittance through each of these vials?

- **A.** 66.7%
- **B.** 35.4%
- **C.** 16.2%
- **D.** 4.0%

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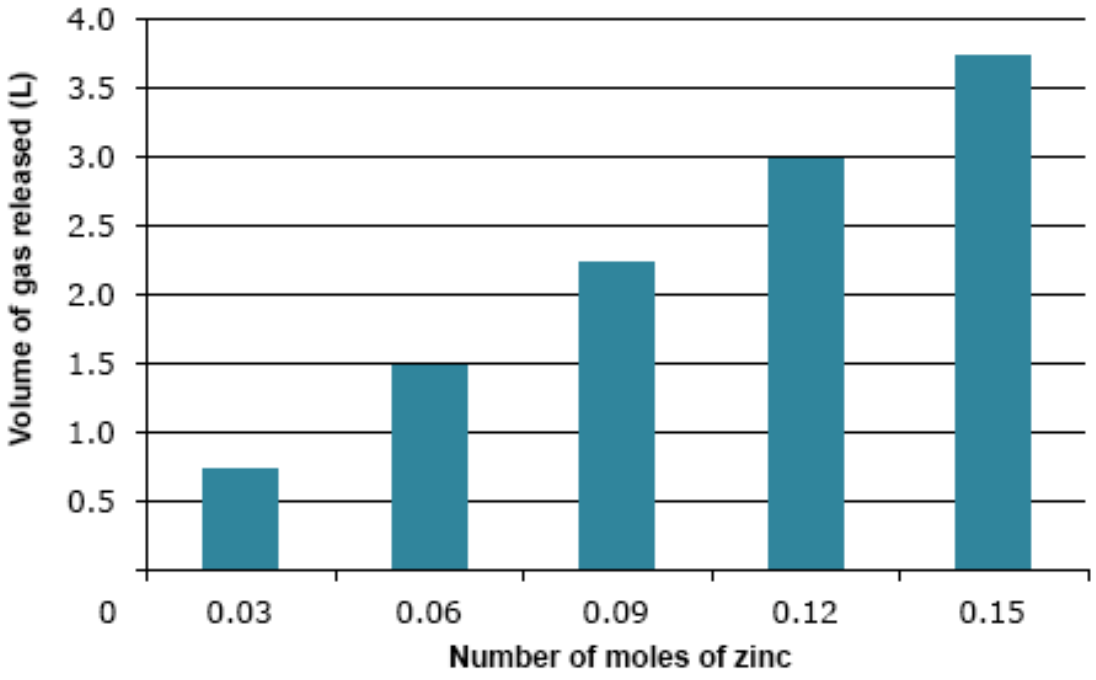

Figure 1

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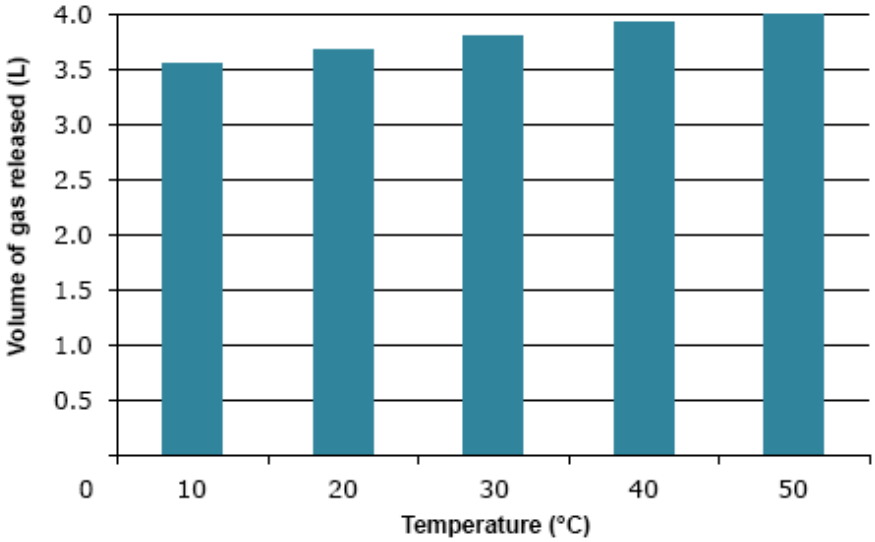

Figure 2

Question 3. Suppose the student repeats the procedure using a different chemical reaction to produce a gas. If 0.12 moles of that reactant produces 1.5 L of gas at 25°C, which of the following statements best compares the two chemical reactions?

- **A.** The two chemical reactions cannot be compared because they involve different chemical reactants.
- **B.** The second reaction produces fewer moles of gas than the first reaction per mole of reactant.
- **C.** Both of the reactions produce equal number of moles of gas per mole of reactant, but the gases produced by the two reactions occupy different volumes.
- **D.** The second reaction produces more moles of gas than the first reaction per mole of reactant.

In a reversible reaction, the reactants form products, and these products react with each other to form the reactants. This takes place by a forward and a reverse reaction, respectively.

These two reactions progress at different rates. After a certain time, the rate of the forward reaction equals the rate of the reverse reaction. At this state, the reaction is in chemical equilibrium. At equilibrium, the concentrations of the reactants and products are constant. If changes are made to conditions like temperature and pressure, the position of chemical equilibrium will shift to balance the changes.

A scientist carried out an experiment to study the effect of temperature on the rate of a reversible reaction. The following reaction was carried out at 25°C.

$$HSO_4^- + H_2O \rightleftharpoons H_3O^- + SO_4^{2-}$$

The concentrations of the reactants and the products were recorded every 20 seconds for 3 minutes. The results obtained are represented in Figure 1.

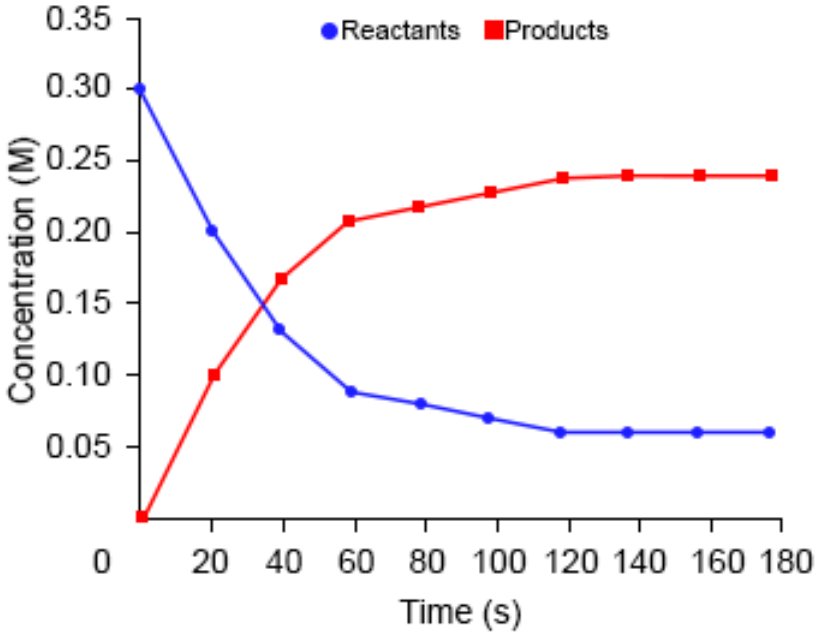

Figure 1

The scientist then carried out the same chemical reaction at 35°C. The results obtained are represented in Figure 2.

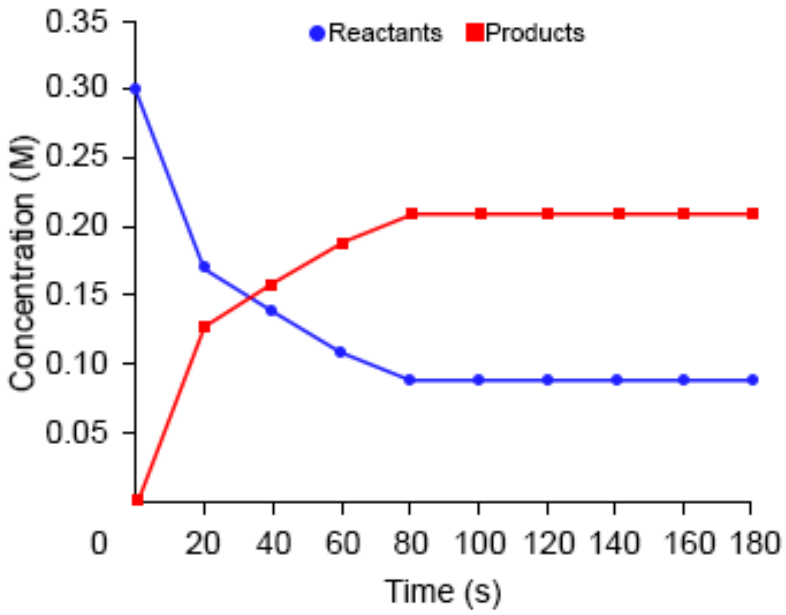

Figure 2

Question 4. Which of the following statements best describes the concentration of HSO_4^- over time in the experiments?

- **A.** The concentration of HSO_4^- decreases until the reaction reaches equilibrium, after which it remains constant.
- **B.** The concentration of HSO_4^- remains constant until the reaction reaches equilibrium, after which it increases.
- **C.** The concentration of HSO_4^- increases until the reaction reaches equilibrium, after which it remains constant.
- **D.** The concentration of HSO_4^- remains constant until the reaction reaches equilibrium, after which it decreases.

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Question 5. What would most likely be the transmittance of a 0.70 M solution of Solute A?

- **A.** 7.6%
- **B.** 1.1%
- **C.** 4.6%
- **D.** 4.0%

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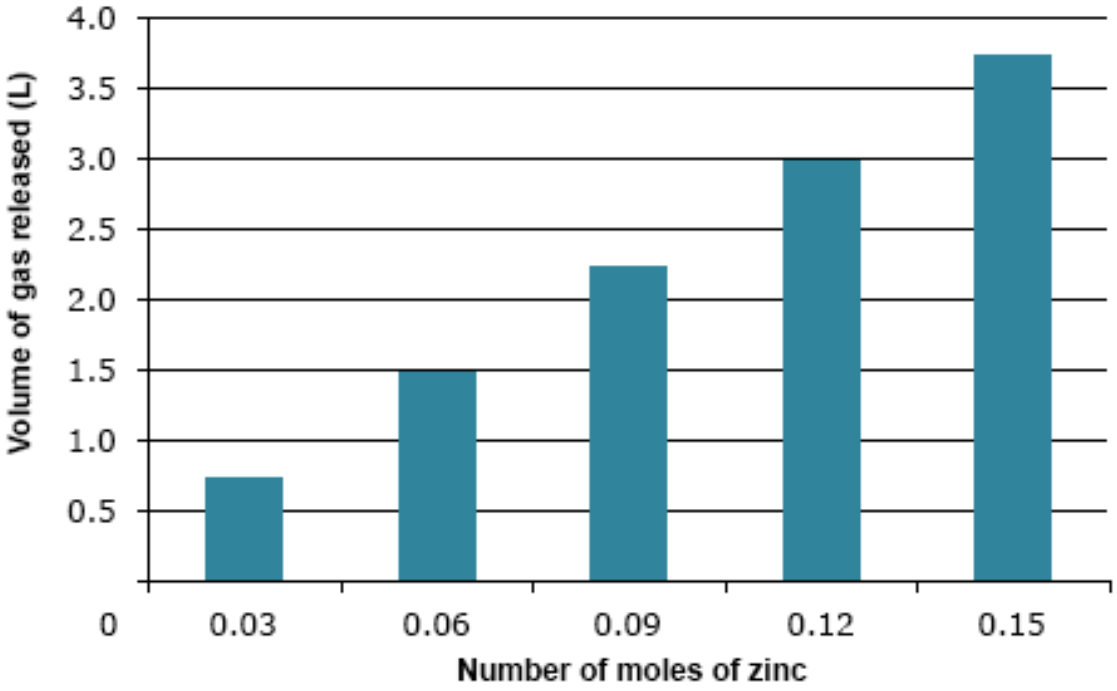

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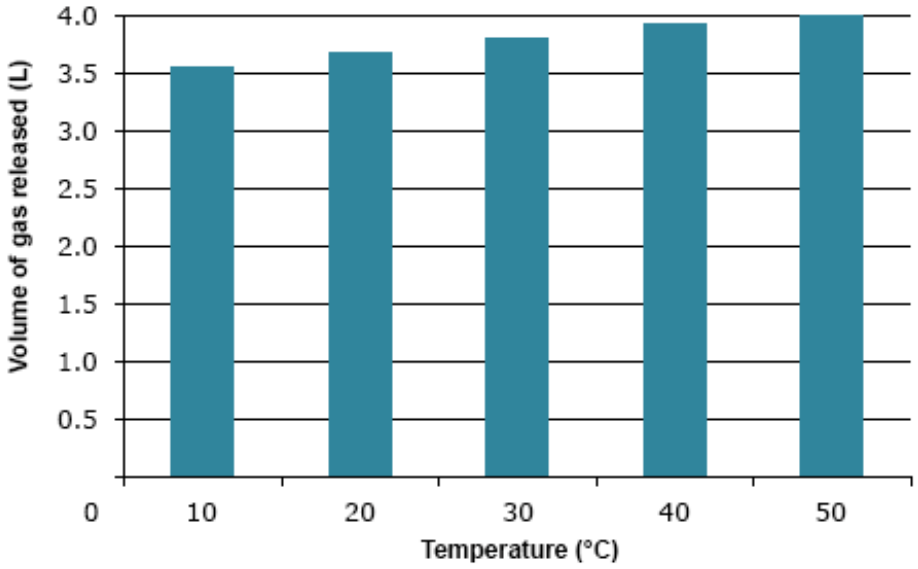

Figure 2

Question 6. Based on the graphs, which of the following statements best describes the correlation between the amount of Zn, temperature, and the volume of gas produced?

- **A.** The volume of gas produced increases as the amount of Zn and the temperature both increase.
- **B.** The volume of gas produced decreases as the amount of Zn and the temperature both increase.
- **C.** The volume of gas produced decreases as the amount of Zn increases and the temperature decreases.
- **D.** The volume of gas produced increases as the amount of Zn decreases and the temperature increases.

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Question 7. Which of the following statements is best supported by the data?

- **A.** Solutions of the same concentration but containing different solutes absorb different amounts of light.
- **B.** The transmittance of a solution depends only on the concentration of the solute.
- **C.** The transmittance of a solution depends only on the intensity of light passing through it.
- **D.** Solutions of the same concentration but containing different solutes absorb the same amount of light.

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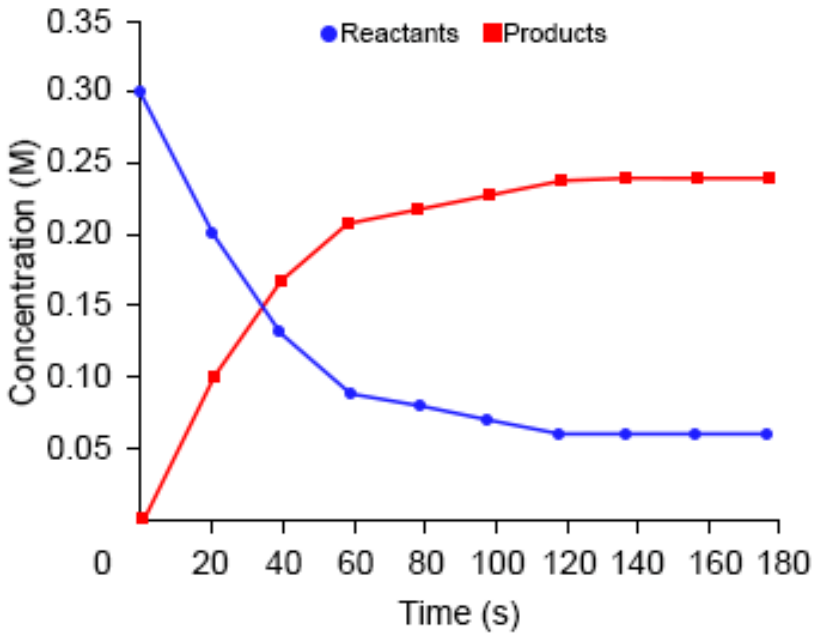

Figure 1

The scientist then carried out the same chemical reaction at 35°C. The results obtained are represented in Figure 2.

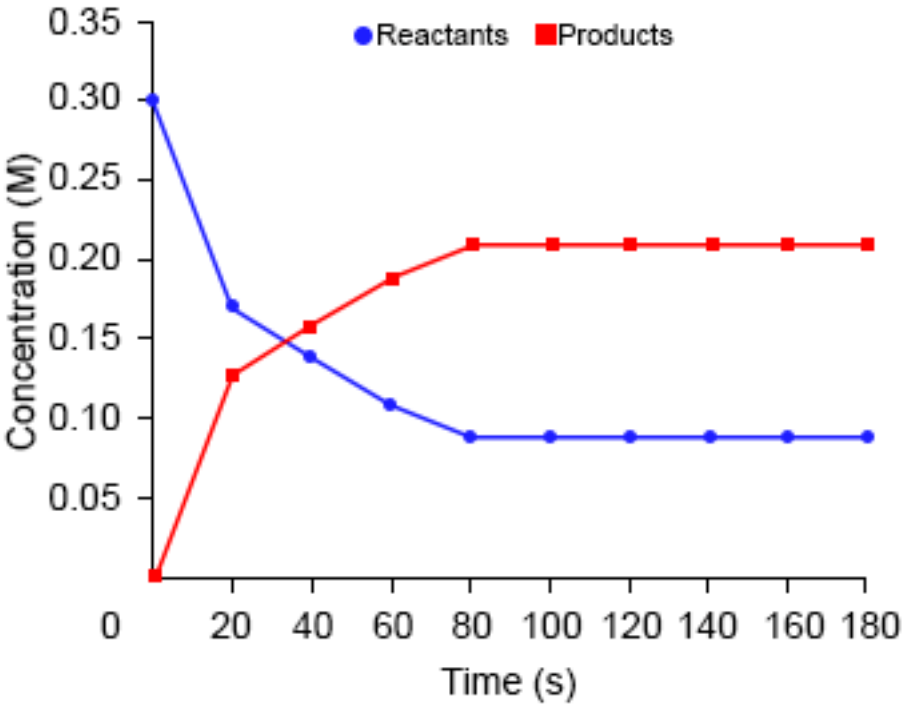

Figure 2

Question 8. If the reaction is carried out at 15°C, how much time would it most likely take to reach equilibrium?

- **A.** 60 seconds
- **B.** 40 seconds
- **C.** 100 seconds
- **D.** 160 seconds

Question 9. From the given figures, describe how the equilibrium position is affected by a change in temperature.

- **A.** The equilibrium position is not affected by a change in temperature.
- **B.** The reaction reaches equilibrium in less time as the temperature increases.
- **C.** The reaction reaches equilibrium in more time as the temperature increases.
- **D.** The reaction does not reach equilibrium with an increase in temperature.

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Question 10. Which of the following statements best summarizes the results of the experiment?

- **A.** The transmittance percentage of a solution increases with an increase in its molarity.
- **B.** The amount of light absorbed by a solution is independent of its concentration.
- **C.** Solutions with higher concentrations transmit more light than solutions with lower concentrations of the same solute.
- **D.** Solutions with higher concentrations absorb more light than solutions with lower concentrations of the same solute.