On the Application of Chart Teaching in Junior High School Chemistry Teaching

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Abstract: Graph is not only the teaching content, vivid, informative and highly relevant knowledge, but also a teaching method in junior high school chemistry teaching. It can show concepts and changes in multiple dimensions, help students overcome learning obstacles and make their thinking explicit.

Keywords: Chart; Junior High School Chemistry; Modeling

1. Introduction

Junior high school chemistry knowledge system is loose, and there are many knowledge points. In teaching, it is necessary to connect and integrate knowledge with charts to help students build a network. Some concepts are abstract. With the help of charts, the variables of concepts can be fully displayed and different dimensions in the same change can be connected. It is a very important teaching method. Changing the variables in the concept of numerical simulation of charts can also make the thinking process explicit, explain the logic between qualitative and quantitative, and help students understand some abstract problems.

Chart, which can be mind map, Euler diagram, function diagram, number axis, flow chart, network diagram, table, etc. It is the application of schema theory to chemistry teaching in junior high school. Rummelhardt, an American expert in artificial intelligence, perfected the complete modern schema theory system on the basis of previous theories: he thinks that schema is a knowledge representation form that organically organizes new things with existing knowledge and experiences in order to facilitate information storage and processing, and is a complete information system composed of interrelated knowledge. Xu Yiqiu thinks that “assimilation” of schema can help students form new concept schema, and “adaptation” of schema can compare the necessary features and irrelevant features between concepts, thus promoting students to form complete chemical concepts. Li Shaokun introduced how to use charts to break through the teaching difficulties in reviewing solution units from the operational level. In this paper, the specific concepts and relationships of solution units are shown by charts, and the students are promoted to understand the core elements of concepts and the relationships between concepts by comparing table information, moving changes of particles in rectangular coordinates and equivalent changes of graphics.

2. The chart is the junior high school chemistry teaching content

2.1 The chart in the book

Many charts[3] in Chemistry of Grade 9 of Shanghai Education Edition show the transformation of materials, the comparison of various data, the microscopic essence of material changes, etc. They are intuitive and visual, especially
the macroscopic problems, which are helpful for beginners to assimilate on the basis of existing knowledge and better understand the microscopic problems.

Figure 1. Carbon dioxide cycle in nature.

Figure 2. Distribution of elements in the crust.

Figure 3. Distribution of elements in seawater.
2.2 Integrate the related information in teaching materials into charts

Some related information in teaching materials is scattered and can be integrated in the form of charts, which is convenient for students to grasp as a whole.

Example: the text description of “the volume fraction of each component in the air” in the teaching material is presented in the form of table and pie chart:

|                | Ammonia | Oxygen | Nobel gas | Carbon dioxide | Others |
|----------------|---------|--------|-----------|----------------|--------|
| Volume percentage | 78%    | 21%   | 0.94%     | 0.03%          | 0.03%  |

Table 1. Volume fraction of each component in air
Figure 6. Volume fraction of each component in air.

Example: integrate the melting point of oxygen and the color state of oxygen into a chart:

Figure 7. Melting point and color of oxygen.

2.3 Select the theme and associate the knowledge points into a chart

Chemical knowledge points are fragmented, so selecting the core topics related to knowledge points and drawing the diagram of knowledge network are helpful for students to construct the knowledge system. There are many forms of this chart, and the author likes to present it in the form of mind map.

Example: properties, changes and smelting of metals[4].

Figure 8. Properties, changes and smelting of metals.

The author also encourages students to draw knowledge network diagrams in the learning process. Example: the following picture shows the knowledge network of “solution” drawn by students:
Such a chart is not only a summary of knowledge, but also can be used as teaching content. Show this chart in the recitation class, and then let the students show their thinking aloud, and recall and express the relevant knowledge points in their own language. It is often recorded when students think aloud, without interrupting the students, and let other students comment and correct errors according to the recording.

3. The chart is the junior middle school chemistry teaching method

3.1 Multi-dimensional display of changes

3.1.1 Show the changing process and simplify the complicated process

Example: Oxygen is produced industrially by separating liquid air. The specific process is as follows: liquefy the air after impurity removal, and then raise the temperature to gasify nitrogen and leave liquid oxygen. In order to help students understand, the author guides students to draw the following images:

![Figure 10](image)

3.1.2 Show multiple dimensions of change and deepen the understanding of change

Example: adding a small amount of calcium oxide solid to saturated calcium hydroxide solution, with the change
of time, the dimensions of the solution change as follows:

![Figure 11. Adding calcium oxide to calcium hydroxide solution.](image)

3.2 Help to clarify the relationship between different dimensions of matter

Many teachers will use the following Figure 12 when explaining the relationship between saturated solution and concentrated or dilute solution. Indeed, this graph can visually show the differences and connections between similar concepts, especially the overlapping part ABCD can help students remember the connection between the state and concentration of solution. However, the author also has different views on this figure. What is the status of the shaded part in Figure 13? Is neither saturated nor unsaturated? In fact, saturation state and solute mass fraction belong to two different dimensions of solution, and it remains to be discussed whether such a chart is scientific or not. In the author's teaching, calculation is often combined with drawing as shown in Figure 14, so that students can calculate and fill in the blanks to help understand the relationship between the two concepts. This design helps students to reason based on evidence and data, instead of taking it for granted.

![Figure 12. Relationship between solutions.](image)
Example: Please complete the following questions according to the information. It is known that the solubility of each substance at 20℃ is as follows:

| Chemical      | Ca(OH)$_2$ | NaCl | KNO$_3$ |
|---------------|------------|------|---------|
| Solubility/g  | 0.165      | 36   | 31.6    |

Table 2. Solubility of substances

At 20℃, add quantitative substances to four beakers containing 100g of water, please fill in the blanks (the shaded part is the reference answer).

| Chemicals   | A          | B            | C           | D            |
|-------------|------------|--------------|-------------|--------------|
| Mass of the solution | 1g Ca(OH)$_2$ | 0.1g Ca(OH)$_2$ | 35g NaCl    | 35g KNO$_3$ |
| Mass fraction of the solute | 100.165g | 100.1g | 135g | 131.6g |
| State       | Saturated | Unsaturation | Unsaturation | Saturation |
| The location in Figure 3 | 4         | 3           | 2           | 1           |

Table 3. Quantitative substances added in 100g water

From the above table, do you think the following statement is correct ( ):

A. The saturated solution is not necessarily a concentrated solution or a dilute solution
B. At the same temperature, the concentration of saturated solution of the same solute is greater than that of unsaturated solution

3.3 The chart method can effectively overcome learning obstacles
Chart teaching should be a method to help students overcome learning obstacles effectively, reduce learning difficulty, construct knowledge network and improve thinking ability. It can’t be reduced to complexity and become a new burden for students. Therefore, the use of chart teaching should be based on students’ existing knowledge, concise and intuitive.

Example: the mixture of iron and a certain metal (6g) reacts completely with enough acid to produce hydrogen (0.2g), and the other metal may be ( ).

A. Al     B. Mg     C. Zn     D. Cu

The mass ratio of several common metals and acids to produce hydrogen can be expressed by the number axis as follows:

The points on this number axis can be expressed as the ratio of metal mass to hydrogen mass, and can also be understood as the ratio of relative atomic mass of metal to valence (except Cu). Using this number axis, it can be easily concluded that the answer to the example is CD.

3.4 The chart can make the thinking process explicit

Whether the application of teaching methods, means and auxiliary tools can improve the teaching effect is not determined by the methods, means and auxiliary tools themselves, but by the matching of the methods, means and auxiliary tools with the problems to be solved, and the fit with the students’ knowledge and ability level in the classroom. Graphs can make some internal thinking processes explicit and visualize the abstract reasoning process in teaching, so as to help students understand and grasp the thinking of solving problems.

Example: in the process of “changing a nearly saturated solution into a saturated solution by increasing solute” (assuming that the temperature is almost constant when solute is dissolved), fill in a form to explain the changes of various elements in the solution (fill in “increasing” or “unchanged” and the shaded part is the reference answer).

| State | Add solute |
|-------|------------|
|       | Unsaturation | Saturation |
| Elements | Mass of the solute | Mass of the solvent | Mass of the solution | Mass fraction of the solute | Solubility |
| Change | Increase | Non | Increase | Increase | Non |

Table 4

Please draw the relationship between the above factors and the mass of added solute. The mass of solute, the mass of solution and the mass fraction of solute can be expressed as:
Solubility and mass of solvent can be expressed as:

There is an inherent constraint in the mass relationship of each dimension in solution, that is, solubility. When learning the knowledge of solubility curve, the meaning expressed by the points on the solubility curve should be fully taken into consideration. When discussing the changes among the elements in the solution, the thinking process explicit with the help of solubility curve should be made, so as to help students deepen their understanding.

Example: The above figure shows the solubility curve of KNO₃. The points of the composition curve can not only represent the solubility of KNO₃ at different temperatures, but also the saturated solution of KNO₃ at different temperatures and the solution with the highest mass fraction of KNO₃ at different temperatures. That is to say, the points in the solubility graph can represent the size relationship of solubility, solution state and solute mass fraction in the solution.

If the temperature of the solution shown at point A is raised, how do the state of solution, solute mass, solvent mass and solute mass fraction change respectively? Analysis process: As can be seen from the image, when the temperature rises, the point should move horizontally to the right, and the point A moves from the curve to the lower curve. It is clearly found that it becomes unsaturated, and the height of the point does not change, so the solute mass fraction does not change. Changing the temperature will not change the quality of solvent, so will the quality of solute.

If the temperature of point B is lowered, how will the above dimensions change?

Analysis process: It can be seen from the image that when the temperature is lowered, the point should move horizontally to the left. Within a certain range, point b only moves in parallel, and when it reaches the curve, it cannot move horizontally to the left, but will slide down the curve. Therefore, after cooling, it began to be unsaturated and then saturated; At first, the mass fraction remained unchanged, and then became smaller. The quality of solvent is unchanged; The mass of solute is constant at first, and then becomes smaller. Through the above analysis, it is not difficult to find that when abstract problems are presented with the method of charts and make the thinking process explicit, it can reduce the difficulty of thinking and help students break through the bottleneck of thinking.

4. Skillfully use the chart model to effectively help solve chemical problems

4.1 Build the reaction process diagram

There are many reactions between substances, and the equations involved are also complex. The model of reaction process can clearly show the process of chemical reaction, straighten out the process of students' thinking, make the process of problem solving tend to be concise, and improve the efficiency of problem solving.

Example 1: 3.8g of the mixture of zinc powder, aluminum powder, iron powder and magnesium powder reacts completely with dilute sulfuric acid with a certain mass solute content of 25%, and the reacted mixture is evaporated to obtain 11g of solid (without crystal water), so the mass of hydrogen generated in the reaction is ( ).
A. 0.15 g  B. 0.20 g  C. 0.30 g  D. 0.45 g

Analysis: The relationship between $SO_4^{2-}$ and $H_2$ can be obtained by constructing the reaction process diagram of the substances in Example 1 (as shown in Figure 16). It is found that the quality of generated hydrogen has nothing to do with the kind of metal (to be able to react), but only with the amount of sulfate (sulfuric acid). Straighten out the thinking of solving problems and choose answer A.

\[
\text{Increase } SO_4^{2-} \ (11 \text{ g} - 3.8 \text{ g})
\]

\[
\begin{align*}
\text{Mg} & \quad \text{Zn} & \quad \text{Fe} & \quad \text{Al} \\
3.8 \text{ g} & & & \\
\text{H}_2\text{SO}_4 & & & \\
11 \text{ g} & & & \\
\end{align*}
\]

Figure 15

\[
\begin{align*}
SO_4^{2-} & \quad \rightarrow \quad H_2\text{SO}_4 & \quad \rightarrow \quad H_2 \\
96 & \quad \rightarrow \quad 2 & \quad x \\
7.2 \text{ g} & \quad \rightarrow \quad x & \quad x = 0.15 \text{ g}
\end{align*}
\]

Figure 16

A certain amount of mixture of MgO and Fe$_3$O$_4$ was added with dilute sulfuric acid containing 19.6g of solute, which was completely reacted. Find the mass of oxygen in the original mixture.

By constructing the reaction process diagram (as shown in Figure 17), it is found that oxygen in the mixture is combined with hydrogen in sulfuric acid to produce water. Because there is a corresponding relationship between the mass of oxygen and the mass of hydrogen in sulfuric acid, the answer is 3.2g.

Figure 17

4.2 To build a schematic diagram of number axes

Establishing number axis can reduce the complicated calculation of chemical equations and simplify the process of solving problems. Acid with the same mass and mass fraction and metal with the same mass are placed on both sides of the balance. When acid reacts with metal, the pointer of the balance will deflect with the change of metal solid mass. There may be three situations: small amount of solid, just reaction of solid and excessive solid. The changing physical quantity is taken as the coordinate of the number axis, and the just-reflected physical quantity is taken as a special point on the coordinate to divide the number axis into several intervals for discussion, as shown in Figure 18.
Figure 18

(1) when \( m \leq 24 \) g, all metals are insufficient (when \( m = 24 \) g, Mg just reacts), the \( H_2 \) released by Mg can be calculated according to metals, and the \( H_2 \) released by Mg is more than that of Fe, so the balance is biased towards Fe;

(2) \( 24 \) g < \( m \) < \( 56 \) g, excessive Mg, insufficient Fe, more \( H_2 \) released by Mg than Fe, so the balance is biased towards Fe;

(3) When \( m \geq 56 \) g, all metals are excessive (when \( m = 56 \) g, Fe just reacts), the released \( H_2 \) can be calculated according to acid, and when acid is equal, the released \( H_2 \) is equal, so the balance is balanced.

Example 2: Inject 100 g of 9.8% dilute sulfuric acid into the beakers on both sides of the balance to adjust the balance, and then put zinc and magnesium with equal mass into the two plates to make the acid react completely. If the balance is still kept in balance, the mass of zinc and magnesium cannot be ( ).

A. Zn: 10 g   Mg: 10 g
B. Zn: 7.5 g   Mg: 7.5 g
C. Zn: 6.5 g   Mg: 6.5 g
D. Zn: 5 g   Mg: 5 g

Answer: The mass of zinc required for complete reaction with 100 g 9.8% dilute sulfuric acid is 6.5 g, and the mass of magnesium required is 2.4 g as shown in Figure 19, the mass range of metal balanced by the balance is greater than or equal to 6.5 g, the answer is D.

Figure 19

5. Conclusion

Graphs not only carry certain teaching contents, but also are important tools and methods for learning chemistry. Image, conciseness and large amount of information are the advantages of chart teaching, which sometimes become the difficulties for students to learn. In junior high school chemistry teaching, in order to give full play to the effect of charts, attention should also be paid to cultivating students’ ability of drawing information from charts, data analysis and data processing.

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