Teaching and Learning Cycle: Scaffolding Students in the Learning of Chemistry

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Explain why sodium chloride has a high melting point.

A typical student response

It has a giant ionic structure.

or

There are strong ionic bonds.

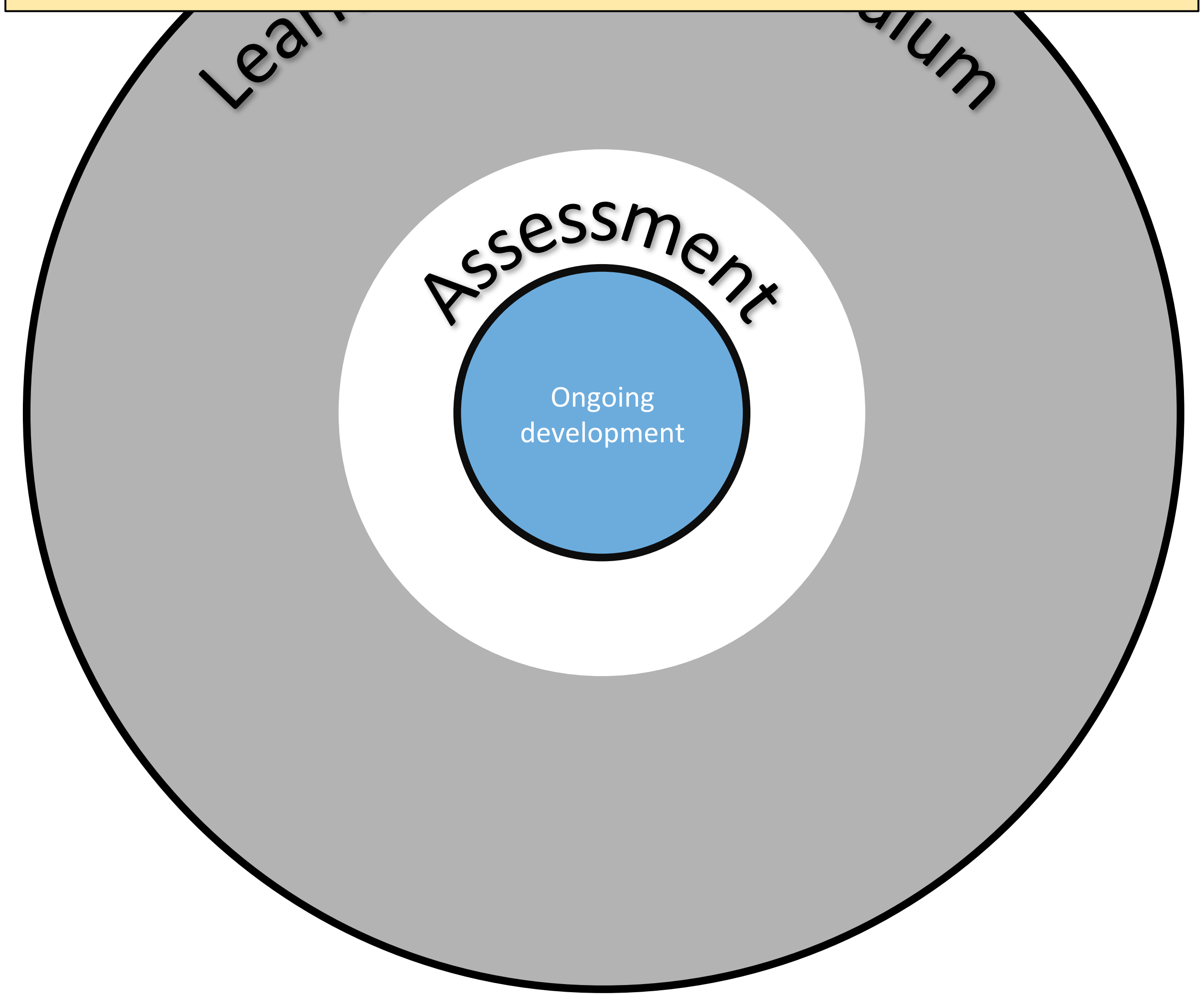
A desirable student response

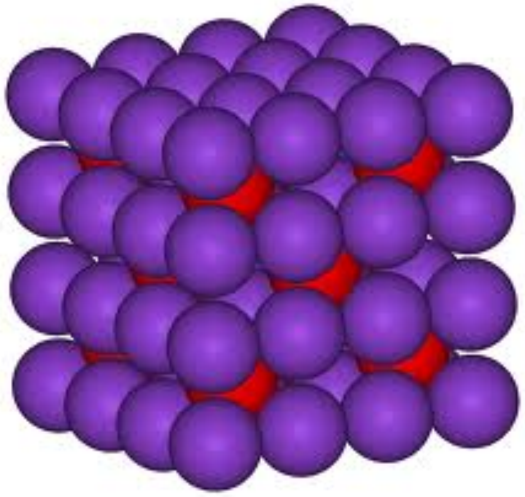
Sodium chloride has a giant ionic structure, which contains positive ions and negative ions.

Positive ions and negative ions are held together by strong ionic bonds, which require a large amount of energy to break.

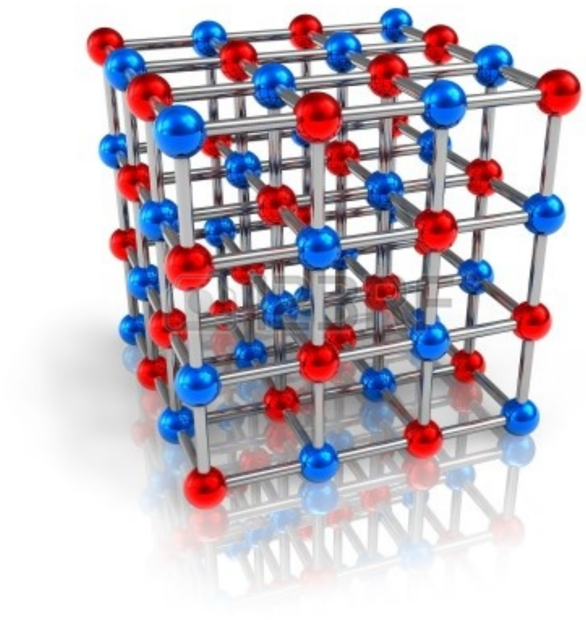
Therefore, it has a high melting point.

SETTING THE CONTEXT
Using pictures, animations and models to show the students the different structures of substances.

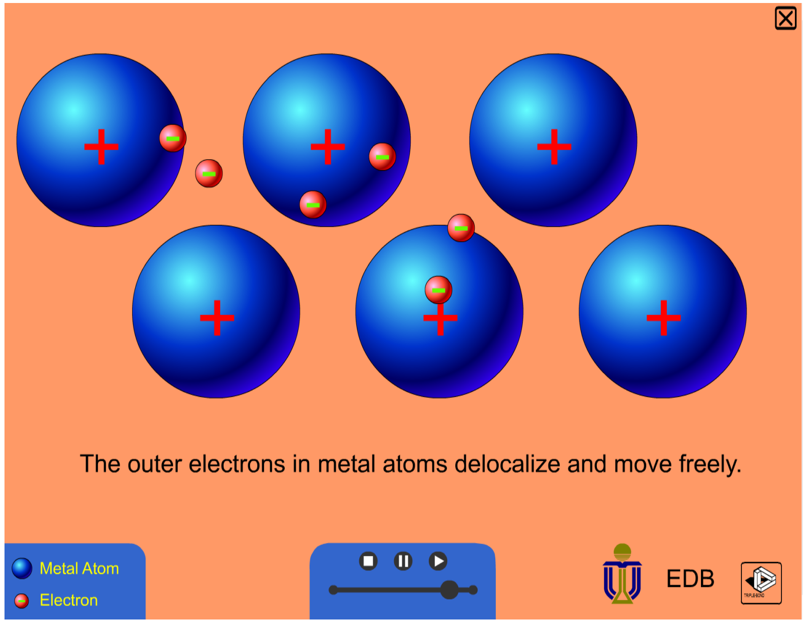




Models
(students can be active in making models)



Animation
(visuals and movement)



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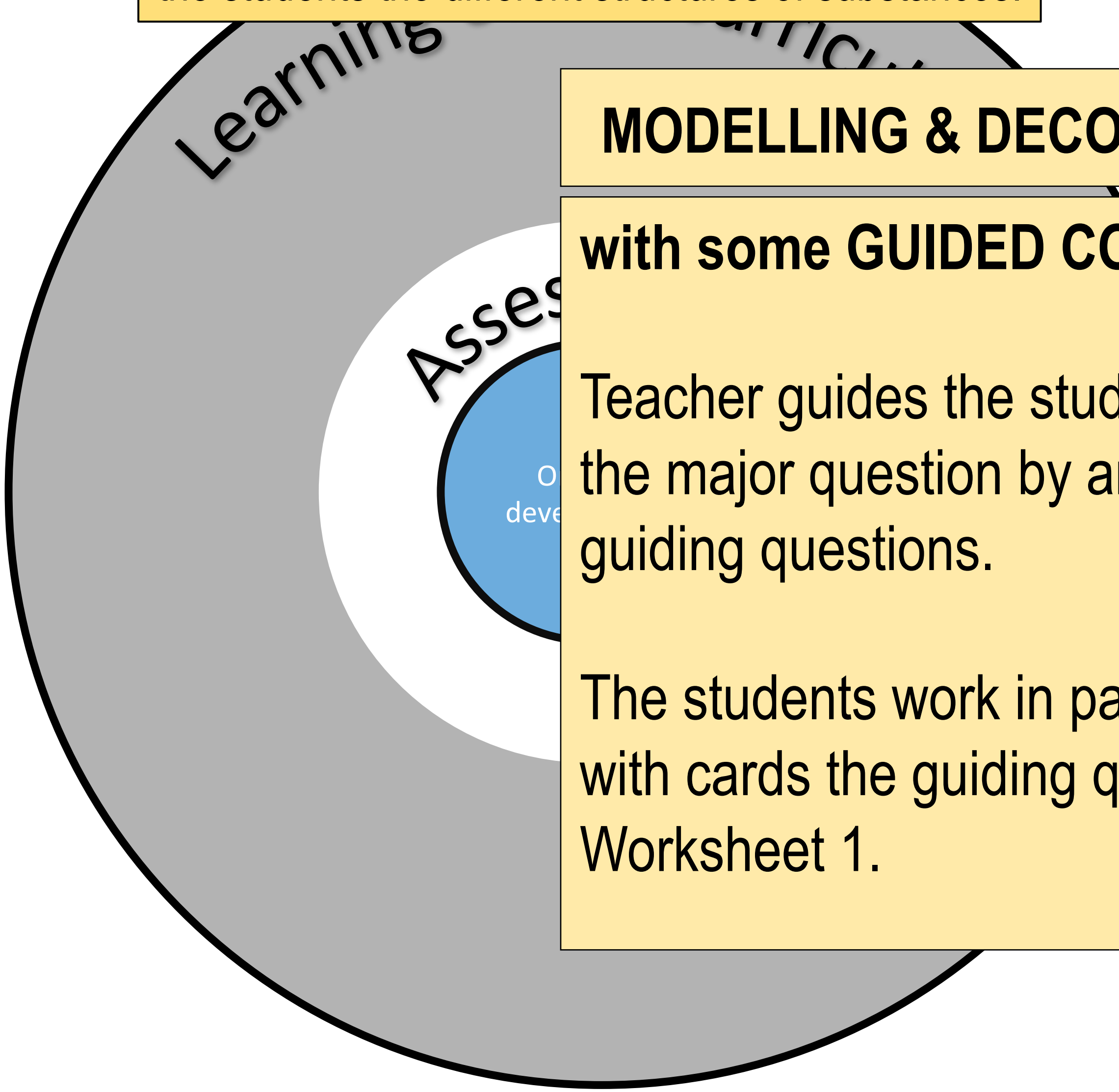


MODELLING & DECONSTRUCTION

with some GUIDED CONSTRUCTION

Teacher guides the students to answer the major question by answering guiding questions.

The students work in pairs to complete with cards the guiding questions in Worksheet 1.

Stuctures	Particles involved	Forces between the particles	Strength of the forces	Amount of energy required to break the forces	Melting point or Boiling point

giant ionic structure

posit ions

molecules

ionic bond

strong

large

high

giant metallic structure

negative ions

covalent bo

strong

large

low

simple molecular structure

atoms

delocalised electrons

metallic bond

strong

covalent bond

small

high

giant covalent structure

atoms

positive ions

Van der Waal's forces

weak

large

high

Stuctures	Particles involved	Forces between the particles	Strength of the forces	Amount of energy required to break the forces	Melting point or Boiling point
giant metallic structure	positive ions delocalised electrons	metallic bond	strong	large	high
giant ionic structure	positive ions negative ions	ionic bond	strong	large	high
giant covalent structure	atoms	covalent bond	strong	large	high
simple molecular structure	(atoms) molecules	(covalent bond) Van der Waal's forces	(strong) Weak	small	low

Worksheet 2

Question:

Explain why sodium chloride has a high melting point.

Answer:

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

Restructured Answer

____

____

____

Explain why sodium chloride has a high melting point.

Guiding questions

- Which **structure** does sodium chloride have?
- What **particles** does the **giant ionic structure** contain?
- By what type of **force** are the **positive ions** and **negative ions** held?
- What is the **strength** of the **ionic bond**?
- How much **energy** does the **strong** ionic bond require to break?
- So, what can we conclude (about the melting point)?

Explain why sodium chloride has a high melting point.

Answers

Sodium chloride has **a giant ionic structure.**

A giant ionic structure contains **positive ions** and **negative ions.**

Positive ions and **negative ions** are held together by **ionic bonds**.

Ionic bonds are **strong**.

Strong ionic bonds require a large amount of energy to break.

Therefore, sodium chloride has a high melting point.

Explain why sodium chloride has a high melting point.

Answers

Combining the answers to Questions 1 and 2, using 'which'.

Sodium chloride has **a giant ionic structure,**

which contains **positive ions** and **negative ions.**

Positive ions and **negative ions** are held together by **ionic bonds**.

Ionic bonds are **strong**.

Strong ionic bonds require a large amount of energy to break.

Therefore, sodium chloride has a high melting point.

Explain why sodium chloride has a high melting point.

Answers

Then incorporating the answer to Question 4 into the adjacent sentences

Sodium chloride has **a giant ionic structure,**

which contains **positive ions** and **negative ions.**

Positive ions and **negative ions** are held together by **strong** **ionic bonds**.

Strong **ionic bonds** require a large amount of energy to break.

Therefore, sodium chloride has a high melting point.

Explain why sodium chloride has a high melting point.

Answers

Finally, we join two of the sentences with 'which' and we end up with the "desirable student response".

Sodium chloride has **a giant ionic structure,**

which contains **positive ions** and **negative ions.**

Positive ions and **negative ions** are held together by **strong** **ionic bonds**,

which require a large amount of energy to break.

Therefore, sodium chloride has a high melting point.

SETTING THE CONTEXT

Using pictures, animations and models to show the students the different structures of substances.

MODELLING & DECONSTRUCTION

INDEPENDENT CONSTRUCTION

Worksheet 2

Students follow the steps in WS 1 to explain the properties of another ionic compound, e.g. potassium iodide.

with some GUIDED CONSTRUCTION

Teacher guides the students to answer the major question by answering guiding questions.

The students work in pairs to complete the guiding questions in Worksheet 1, with cards.

Worksheet 2

Question:

Explain why potassium iodide has a high melting point.

Answer:

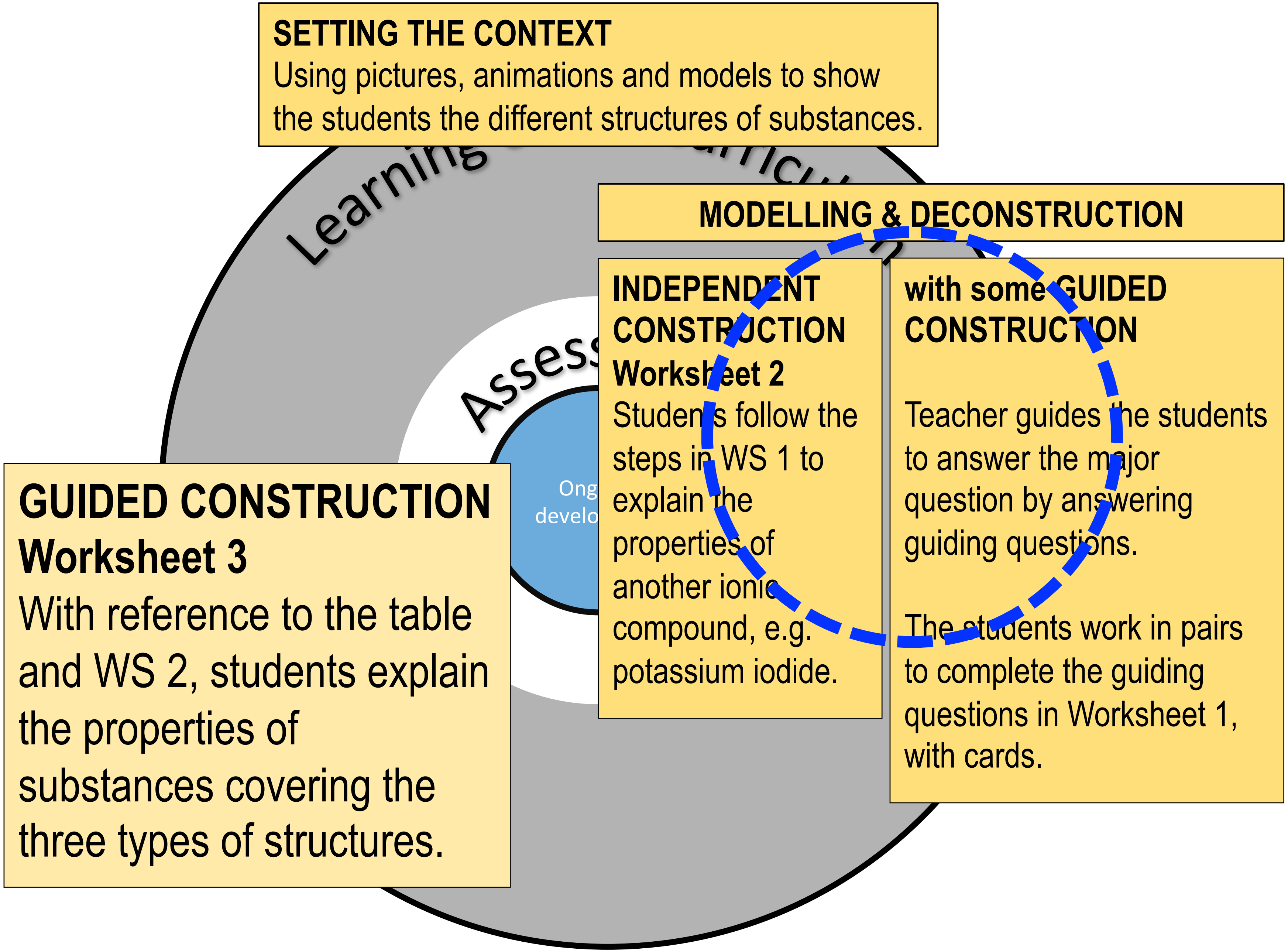
1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

Restructured Answer

____

____

____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Teacher guides the students to answer the major question by answering guiding questions.
The students work in pairs to complete the guiding questions in Worksheet 1, with cards.
GUIDED CONSTRUCTION
Worksheet 3
With reference to the table and WS 2, students explain the properties of substances covering the three types of structures.

Worksheet 3

Question:

1. Explain why diamond (textbook p.59) has a high melting point.

Answer:

____

____

____

2. Explain why iodine (textbook p.76) has a low melting point.

Answer:

____

____

____

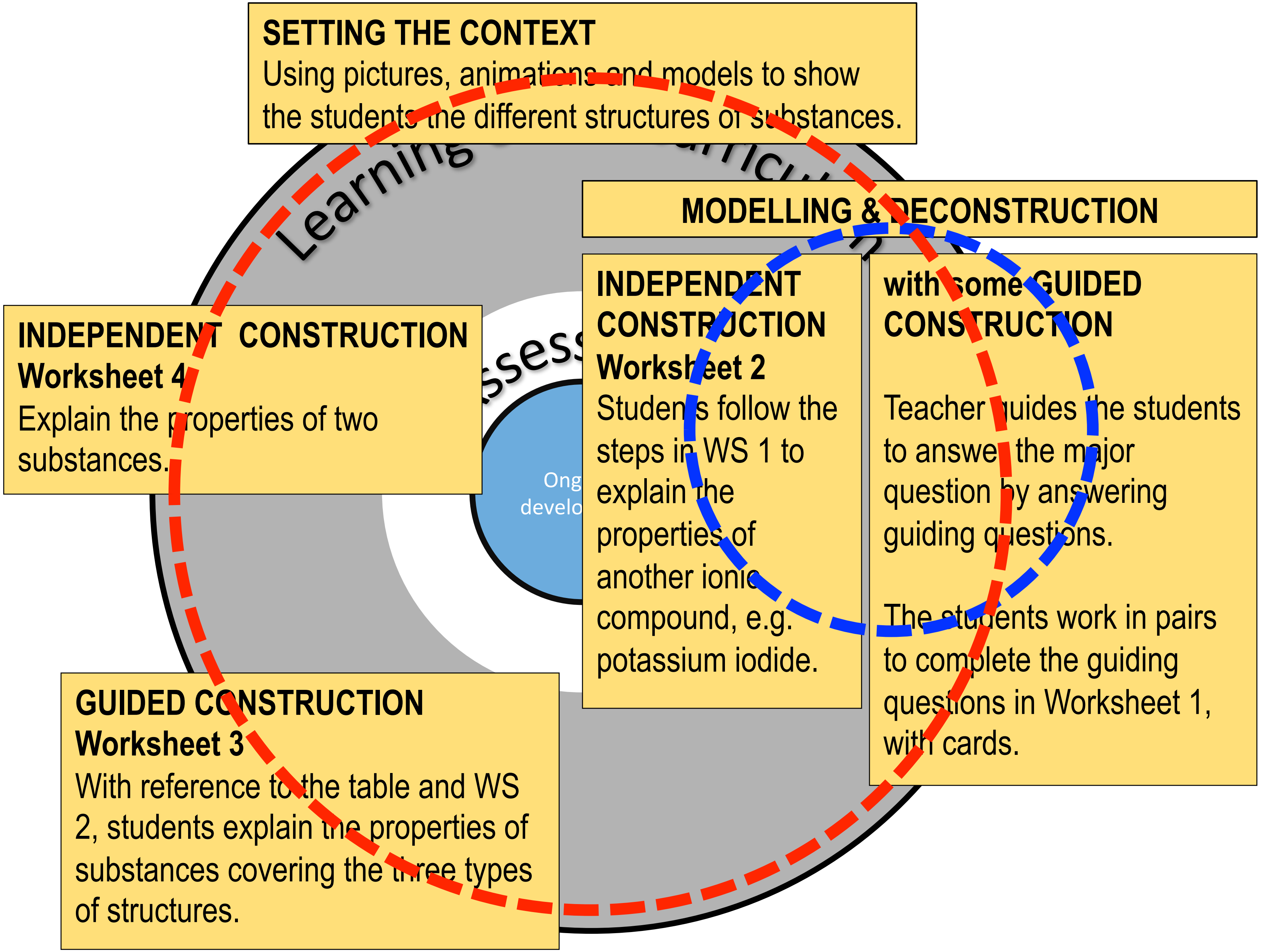
3. Explain why iron has a high melting point.

Answer:

____

____

____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Worksheet 2
Students follow the steps in WS 1 to explain the properties of another ionic compound, e.g. potassium iodide.
with some GUIDED CONSTRUCTION
Teacher guides the students to answer the major question by answering guiding questions.
The students work in pairs to complete the guiding questions in Worksheet 1, with cards.
INDEPENDENT CONSTRUCTION
Worksheet 4
Explain the properties of two substances.
GUIDED CONSTRUCTION
Worksheet 3
With reference to the table and WS 2, students explain the properties of substances covering the three types of structures.
Learning

Worksheet 4

Question:

1. Explain why silicon has a high melting point.

Answer:

____

____

____

2. Explain why hydrogen sulphide has a low melting point.

Answer:

____

____

____

Classroom context 1

- S4 students
- Attentive but not confident, so they are passive
- About one-third of students studied in Chinese in S3
- Not good at writing in English — gave short answers in S3

Warm up and reflection

Students are given a work sheet and asked to write a short paragraph to explain why sodium chloride has a high melting point.

The objective is to collect some baseline data and identify what they can do prior to the lessons.

Students work as a group to link concepts

Students are given a set of cards according to the table of 6 columns and guiding questions to link the concepts:

structure → particles involved → force involved → strength of force → energy needed to break the force → conclusion.

Students work as a group to link the concepts

Students use guiding questions

Students use guiding questions

Students rewrite the answer in a paragraph

St

Question

Explain why sodium chloride has a high melting point.

First Draft

→ Sodium chloride is a giant ionic compound. It needs a lot of energy to seperate.

→ Sodium is a metal which in a form at solid stage. To melt a solid it need a lot of energy to break down the sodium in a ionic bond.

wrong concept

First Draft

It's because it ~~formed~~ formed by ionic bond which ~~has~~ is a strong electrostatic force.

Therefore, Ionic ~~bond~~ compounds usually have high melting pt where more energy is needed

Mind the use of the terms!

First Draft

Sodium chloride has the giant Ionic structures. elaborate.....

....

Question

Explain why sodium chloride has a high melting point.

why?

First Draft

Sodium chloride (NaCl) which ~~is~~ has giant Ionic structure.

Giant Ionic structure has a high a melting point propertie

Therefore, sodium chloride has a high melting point.

Explain in terms of bonding + the strength of bonding!

Second Draft (Restructured Answer)

Sodium chloride has a giant ionic structure which contains positive ions and negative ions. Positive ions and negative ions are held together by strong ionic bonds which requires a large amount of energy. Therefore, it has a high melting pt.

Second Draft (Restructured Answer)

Potassium iodide has an giant ionic structure, which contains positive ions and negative ions. They are held together by strong ionic bond. It requires a large amount of energy to break. Therefore it has a high melting point.

Good!

Second Draft (Restructured Answer)

Sodium chloride has a giant ionic structure which contains positive ions and negative ions. Positive ions and negative ions are held together by strong ionic bonds which requires a large amount of energy. Therefore, it has a high melting pt.

Second Draft (Restructured Answer)

NaCl has a giant ionic structure which contains positive ions and negative ions. Positive ions and negative ions are held by strong ionic bonds which requires a large amount of energy to break. Therefore, NaCl has a high melting point.

Good!

Potassium Iodide has a giant Ionic structure which contains negative Ions and positive Ions. Positive Ions and negative Ions are held together by strong Ionic bonds, which require a large amount of energy to break down. Therefore, It has a high melting point.

Good!

First Draft

Potassium Iodide has a giant ionic structure, which contains positive ions and negative ions. Positive ions and negative ions are held together by strong ionic bonds, which require a large amount of energy to break. Therefore, it has a high melting point.

Good!

Second Draft (Restructured Answer)

Potassium Iodide has a giant ionic structure, which contains positive ions and negative ions. Positive ions and negative ions are held by strong ionic bond which require a large amount of energy to break. Therefore, KI has a high melting point.

Good!

Question

Explain why potassium iodide has a high melting point.

First Draft

Potassium Iodide has a giant ionic structure which contains negative ions and positive ions. Positive ions and negative ions are held together by strong ionic bonds, which require a large amount of energy to break down. Therefore, it has a high melting point.

Good!

Students applying the skills to solve other problems

Task 1

Explain why diamond has a high melting point.

Answer

~~As~~ diamond has a giant covalent structure which contains carbon atoms. Carbon atoms are held by strong covalent bond. (Strong which covalent bond) requires a large amount of energy to break. Therefore, it has a high melting point.

Good!

Students applying the skills to solve other problems

Task 1

Explain why iodine has a low melting point.

Answer

Iodine has a simple molecular structure which contains Iodine molecules. Iodine molecules are held by weak vander Waal's force which requires small amount of energy to break down. Therefore, Iodine has a low melting point.

Good!

Students applying the skills to solve other problems

Task 1

Explain why iron has a high melting point.

Answer

Iron has a giant metallic structure which contains positive ions and delocalised electrons. Positive ions and delocalised electrons are held by strong metallic bond which requires large amount of energy to break down. Therefore, Iron has a high melting point.

Good!

Findings

- All students write better after the activity.
- The weaker students have more significant improvement after the activity.
- About 15% of the students have problems in connectives in the second draft.
- Over 90% of the students can apply the skills learnt to answer similar questions.
- Many of the students still have problems with the particles involved, especially simple molecular structures.

Reflections

- Students have confidence in handling questions requiring explanations if they are taught how to present their ideas.
- Students' concepts can be strengthened if an effective way of linking up the concepts is taught.
- Students should be given more chances to present their ideas so that any learning difficulties can be more easily identified.

Classroom context 2

- S5 students
- The following is a plan for what could be implemented.

Investigating the equilibrium system of

$$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow [Fe(SCN)]^{2+}(aq)$$

to study the shift of equilibrium positions upon concentration changes

$$Fe^{3+}(aq) \quad + \quad SCN^{-}(aq) \longleftrightarrow [Fe(SCN)]^{2+}(aq)$$

$Fe^{3+}(aq)$ ions

$SCN^{-}(aq)$ ions

$[Fe(SCN)]^{2+}(aq)$ ions

Change	Observation	Change in concentration $[Fe(SCN)]^{2+}(aq)$ ions	Shift of position of equilibrium
Increasing $[Fe^{3+}(aq)]$	A darker colour appears.	increases	To the right
Increasing $[SCN^{-}(aq)]$	A darker colour appears.	increases	To the right
Decreasing $[Fe^{3+}(aq)]$	A lighter colour appears.	decreases	To the left

For each change, explain how the shift in the position of equilibrium conforms to Le Chatelier's principle.

When the concentration of $Fe^{3+}(aq)$ ions increases, the system responds by reducing this change. A net forward reaction occurs to use up some of the $[Fe^{3+}(aq)]$ ions. The position of equilibrium shifts to the right.

When the concentration of $SCN^{-}(aq)$ ions increases, the system responds by reducing this change. A net forward reaction occurs to use up some of the $SCN^{-}(aq)$ ions. The position of equilibrium shifts to the right.

When the concentration of $Fe^{3+}(aq)$ ions decreases, the system responds by reducing this change. A net backward reaction occurs to produce more $Fe^{3+}(aq)$ ions. The position of equilibrium shifts to the left.

From the above table, it is hard for students to understand that the increase/decrease in concentration of $[Fe(SCN)]^{2+}$ (aq) is making a reduction against the change.

Therefore, I have designed two tables to correlate "**the changes in darkness of the colour of the mixture**" to "**the change in concentrations of all the three species**".

TABLE 1

Case	Change	Observation
1	Increasing [Fe^{3+}(aq)]	The mixture turns darker.
2	Increasing [SCN^{-}(aq)]	The mixture turns darker.
3	Decreasing [Fe^{3+}(aq)]	The mixture turns lighter.

$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow [Fe(SCN)]^{2+}(aq)$

yellow colourless deep red

	Change in $[Fe^{3+}(aq)]$	Change in $[SCN^{-}(aq)]$	Change in $[Fe(SCN)^{2+}(aq)]$
The mixture turns darker	decreases	decreases	increases
The mixture turns lighter	increases	increases	decreases

Then, through a series of guiding questions, students are led to being able to write three explanations making explicit the causal relations.

When the concentration of Fe^{3+}(aq) is increased, what will the system do to the concentration of the Fe^{3+}(aq)?

When the concentration of Fe^{3+}(aq) is increased, the system will decrease it.

To make such a change, will the system carry out a net forward or backward reaction?

To make such a change, the system will carry out a net forward reaction.

Therefore, to which side will the position of the equilibrium shift to?

The position of the equilibrium will shift to the right.

I will then teach them how to restructure these sentences into a short explanation.

Explain the response of the system in Case 1 when the concentration of $Fe^{3+}(aq)$ is increased.

When the concentration of $Fe^{3+}(aq)$ is increased, the system will decrease it.

~~To make such a change,~~ the system will carry out a net forward reaction. And then we tighten up the text further.

The position of the equilibrium will shift to the right.

Explain the response of the system in Case 1 when the concentration of $Fe^{3+}(aq)$ is increased.

When the concentration of $Fe^{3+}(aq)$ is increased, the system will decrease it.

The system will carry out a net forward reaction.

The position of the equilibrium will shift to the right.

Explain the response of the system in Case 1 when the concentration of Fe^{3+}(aq) is increased.

When the concentration of Fe^{3+}(aq) is increased, the system will decrease it.

And then we add explicit causality.

The system will carry out a net forward reaction, **so** the position of the equilibrium will shift to the right.

Explain the response of the system in Case 1 when the concentration of Fe^{3+}(aq) is increased.

When the concentration of Fe^{3+}(aq) is increased, the system will decrease it. The system will carry out a net forward reaction, so the position of the equilibrium will shift to the right.

And, finally, I will ask them to explain the responses of the system in Cases 2 and 3 in the same way.

Thank you.