States of Matter

Missing title Text

Matter is anything that occupies space and has mass. All matter exists in at least three states: solid, liquid and gas depending on temperature and pressure. All three states of matter consist of particles, whose behaviour determines the state and the energy required for bond making and bond breaking. In fact, the differences in spacing and speed are some of the main reasons for the different properties of the three states of matter.

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Solids can be either crystalline or amorphous. The particles composing a crystalline solid, such as diamonds or salt, have an ordered internal arrangement. Solids that do not have a fixed, symmetrical internal structure are called amorphous. A species comprising an amorphous solid is a permanently super-cooled liquid, such as glass. Due to their fixed shape or volume, solids cannot be compressed or expanded. Although solids feature a high degree of order, their particles tend to vibrate about fixed positions and their vibrations increase with increasing energy supply. When sufficient energy is supplied, solid particles overcome the attractive (cohesive) forces that keep them together and they separate.

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As in solids, liquid particles are very close together, but there is no regular or ordered arrangement. They exhibit considerable mobility, which increases as the temperature rises. In liquids there is a short-range order and a long-range disorder; hence, we often claim that they are in between the ordered solid state and the random gaseous state. Their molecules are in constant motion and they take the shape of the container they are in. Also, near the surface their molecules cohere more strongly to the molecules adjacent to them featuring a property known as surface tension. As such, liquids with low surface tension tend to evaporate. With the provision of more energy, liquid molecules can also overcome the attractive forces and enter the vapour phase through evaporation. The temperature drops as soon as liquid molecules turn into gas. The energy required for this separation is called heat of vaporisation and there are two key physical properties of liquids relevant to it; boiling point and pressure. The boiling point corresponds to the temperature at which the vapour pressure of the liquid equals the surrounding environmental pressure. Yet, boiling point is proportional to pressure. The lower the pressure, the lower the boiling point. Increasing the pressure applied raises the boiling point.

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The gaseous state is a totally disordered state of matter in which particles are in constant motion and attractive forces between them are negligible. In the gas state, particles have broken away from each other and are free to move around. Their random motion leads to collisions that are very elastic so there is little loss of kinetic energy. Gases that obey Boyle's law are known as Ideal Gases and obey the following equation PV = *k* where *P* is the pressure of the gas, *V* is the volume of the gas, and *k* is a constant. e more easily.

Gases compress or expand to fill the available space and exert a uniform force i.e. pressure on the walls of their container. However, the concepts of pressure and temperature deserve a little more discussion. The former is a measure of the force exerted by a gas per unit area with SI units of Newtons per square metre (Nm-2), more commonly referred to as Pascals (Pa). The latter is a measure of the average translational kinetic energy of the molecules. In a hot gas, for example, the molecules are faster than those in a cold gas; due to the increased velocity of the molecules, the temperature (i.e kinetic temperature) is greater while the mass remains the same.

Mixtures and pure substances

In terms of composition, matter can also be divided to **pure substances** and **mixtures**. Pure substances, such as elements, cannot be chemically separated or **decomposed** into simpler substances. On the other hand, a chemical combination of an element is a **compound**. Mixtures are divided into heterogeneous and homogeneous. The former consists of **discernible** parts or **phases** (Fig 1) whereas the latter is made up of **components** that cannot be individually detected. Homogeneity can be found in uniform solutions. The particles in suspensions are larger than those found in solutions.Being heterogeneous, components of a suspension such as oil and water can be evenly distributed by mechanical means, i.e. by shaking the contents, but eventually they settle out. Unlike suspensions, the dispersed particles of colloid are not as large and they do not settle out upon standing and unlike solutions, they are not dissolved in the medium they are contained. A colloid is a heterogeneous mixture in which the dispersed particles are intermediate or relatively small in size between those of a solution and a suspension.

Reading comprehension

Task 4 Scan the text and explain why the following statements are true or false.

a Solids maintain relative definite volumes.

b Solids are practically incompressible.

c Liquids maintain definite volume and are relatively incompressible.

d Liquids conform to the shape of the bottom of a container.

e Liquids exhibit the long-range order characteristic of crystalline solids.

f The gas particles are in constant motion and eventually collide with the walls of their container causing pressure.

g A heterogeneous mixture is a non-uniform mixture that retains its own unique properties.

Task 5 Match the terms with their definitions

Solid	**a**	It has no fixed volume and spreads out to fill its container.
Liquid	**b**	The smallest particle of an element that enters chemical reactions.
Gas	**c**	It has definite volume which is sustained under normal conditions.
Atom	**d**	A pure substance that cannot be broken into smaller substances
Molecule	**e**	It has a definite volume but it takes the shape of its container.
Element	**f**	The smallest particle of a compound that retains its properties.
Compound	**g**	It is a uniform in composition and homogeneous mixture.
Solution	**h**	It is a pure substance composed of chemically combined elements.

Task 6 State whether each of the following processes involves physical or chemical changes: For example, Carbon burns (reacts) with oxygen to form carbon dioxide. (It is chemical since its chemical composition has changed).

a Dissolving coffee and sugar

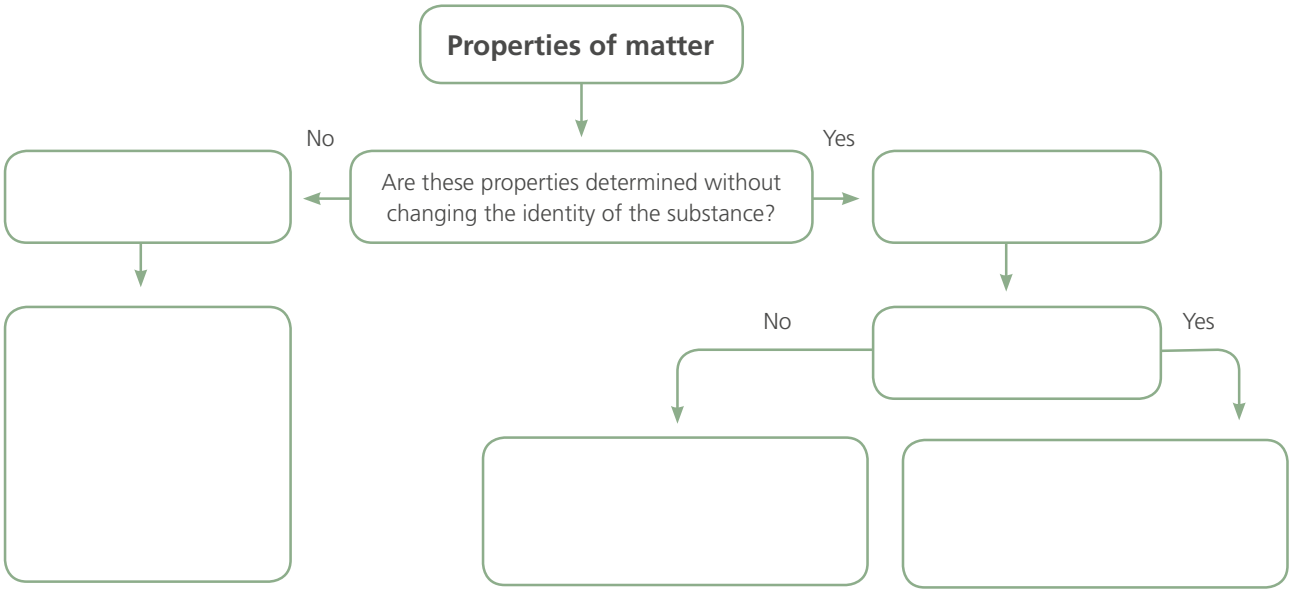
b When iron reacts with oxygen

c Water freezing

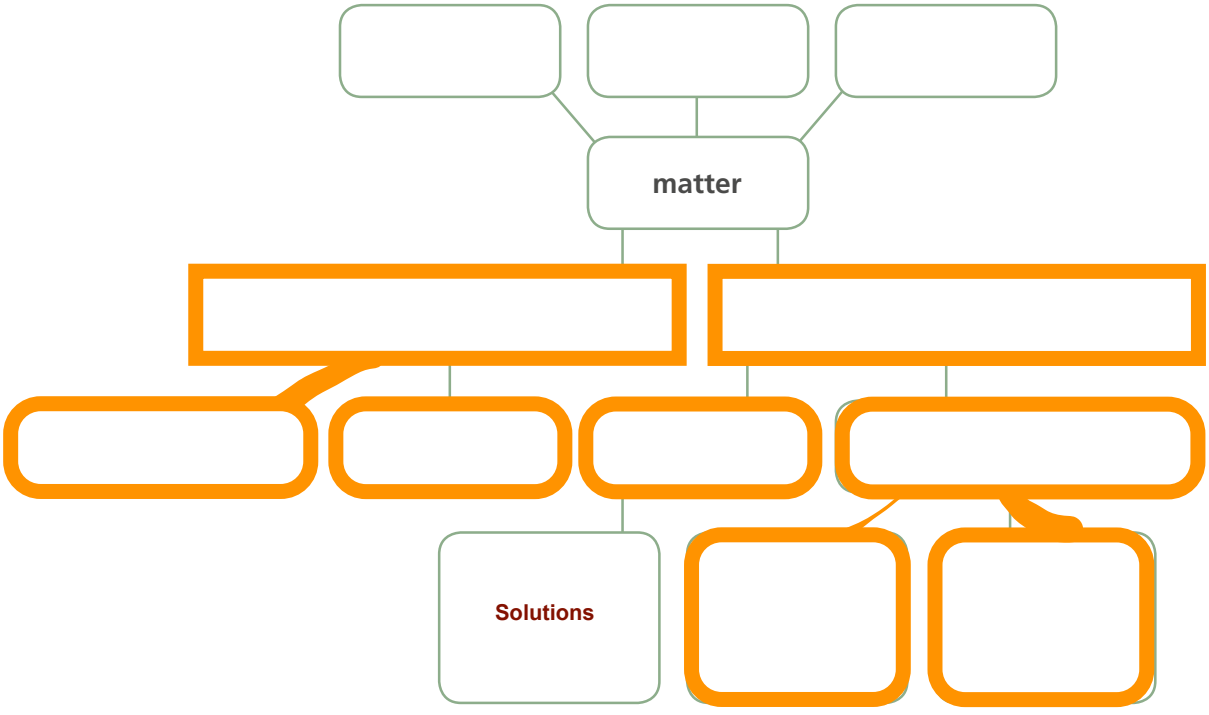
d When milk sours

e Burning wood

Task 7 Read the paragraph on Physical and Chemical properties and complete the missing information.

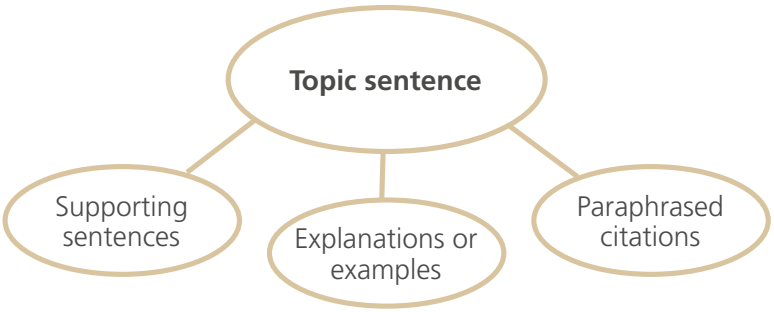


Task 8 Read the text carefully and complete the missing information about types of matter.



Writing Strategies Identifying Topic Sentences

Topic sentences highlight the main points in the whole paragraph. They are the most important sentences in the paragraph as they can be used as excellent signposting or summarising devices. When you write a paragraph, make sure you write a topic sentence that serves as an umbrella sentence that incorporates all points raised later on (details, evidence, statistics) in a cohesive way.



Task 9 Underline the topic sentence in each paragraph.

a In which part of the paragraph did you locate it? Check with your partners to see if you agree.

b What is the main purpose of a topic sentence?

c What other moves follow topic sentences in a paragraph?

d Read the following paragraph and identify the topic sentence, the support sentence (evidence, clarification, expansion) and details (examples or statistics).

Over the years, there has been a growing interest in variables predicting student success in first year university chemistry programmes because unsatisfactory grades obtained in these courses are one of the reasons students migrate out of Science and Technology pathways. Hence, if professors can predict which students might struggle in chemistry courses would allow them to modify their curriculum to scaffold those students most at risk. There have been numerous studies that have examined various factors to determine their predictive ability such as general math ability (1–5), formal thought(6), scientific reasoning ability (7), affective characteristics

(8–10) and language comprehension (11). In fact, over many years chemical education researchers have been examining how students solve problems and whether students are understanding the concepts behind the problems or just solving the problems algorithmically (12–14). In addition, even some students with excellent preparation and high ability (based on standard preparation exams) are found to be struggling in these lower-level chemistry courses (15–17). Thus, intense interest in identifying which students will struggle in these key introductory science courses remains and adequate actions need to be taken (18).

Frey R. F. et al. (2017) Students' Concept-Building Approaches: A Novel Predictor of Success in Chemistry Courses Journal of Chemical Education, 94 (9), pp 1185–1194

Vocabulary building

Collocations

When you come across new words, it is useful to record collocations of these words that is the phrases that the word typically occurs in. For example, a typical collocation of "occupy" is "occupy space or time".

Task 10 Match the verbs below with the words or phrases they can be used with.

a	Occupy	reactions, change
b	Expand	temperature
c	Dissolve	force
d	Rise	food
e	Exert	substances
f	Transform	pressure
g	Undergo	a gas
h	Compress	matter
i	Digest	space

Task 11 Use single words or phrases listed in the previous task that best fit each space. Not all words are used.

a When aluminium oxide is ..... in sodium hydroxide solution, it forms sodium aluminate.

b Steel, glass and cement, which are made from raw materials, ... chemical reactions.

c Liquids and solids have their particles very close together so it is very difficult to .....

d Gases ..... a uniform ..... on the walls of the vessel they are contained.

e As the ...., gaseous particles are in continuous rapid motion with increasing speed.

Vocabulary building

Adjective suffixes

- Most common adjectives do not have a particular ending:

  hard, large, long, gold, high, heavy

- Other adjective suffixes are:

-al	physical, chemical
-ous	aqueous, homogeneous
-ful	useful, harmful
-less	useless, harmless
-ive	productive, passive, selective
-ent	dependent, competent
-ar	circular, triangular
-able	biodegradable, reliable, scalable
-ible	edible, flexible, reproducible

Task 12 Word formation. Fill in the missing adjectives.

ADJECTIVES	NOUNS
	difference
	symmetry
	regularity
	gas
	liquid
	availability
	hardness
	heterogeneity
	discernment
	rigidity

Task 13 Use the words given in the table to complete the gaps.

a The steaming hot tea is a two-phase system; that is, the ..... phase (steam) and the ..... phase (tea).

b The ..... of the metal caused it to fracture.

c A salt and sand mixture is a ..... mixture since the two substances cannot be broken down any further.

d There is a clear ..... in compressibility among solids, liquids and gases.

e Anisotropic arrangement is denoted by the non-..... nature of molecules.

Note-taking skills linear style with abbreviations and symbols

University students take accurate notes during lectures in order to use them later on. In terms of organisation and note-taking styles, they may opt for a linear pattern coupled with abbreviations and symbols. Two common features of a linear pattern is capital letters for titles, indentation, numbering and lettering. Indentation works on the principle that the more general information elements go on the left of your page whereas the more detailed ones are located on the right hand side. It is common to use abbreviations and symbols to save time. Common abbreviations and symbols are:

m	mass
H	Hydrogen
IF	Intermolecular forces
aq.	aqueous phase
anhyd	anhydrous
ppt.	solid precipitate
Mr, MW	molecular weight
H_20	water
NIR	Near Infrared
NMR	Nuclear Magnetic Resonance
DNA	Deoxyribonucleic acid
bp	boiling point
SE	standard error
σ, SD	standard deviation
ppb	parts per billion
c.	approximately, about(Latin 'circa')
e.g.	for example i.e. in other words
w/	with

w/o	without
v.	very
vv.	extremely
etc.	and so on
vs.	(versus) against
& or +	and, plus, with
–	minus, without
=	equals, is the same as, results in
≠	does not equal, is not the same as, does not result in
≈	is similar to
<	is less than
>	is greater than
↑	increase, rise, growth
↑↑	rapid increase
↓	decrease, fall, shrinkage
→	leads on to, produces, causes
x	no, not, incorrect
✳	important, special

Task 14 You are going to listen to a description on the states and properties of matter. Complete the student's linear notes using abbreviations and symbols.

4 STATES OF MATTER

has m + occup. space

A SOLIDS (S)
- **a**
- **b**
- **c**

B LIQUIDS (L)
- **a**
- **b**
- **c**

C GASES (G)
- **a**
- **b**
- **c**

D PLASMA (P)
- **a**
- **b**
- **c**

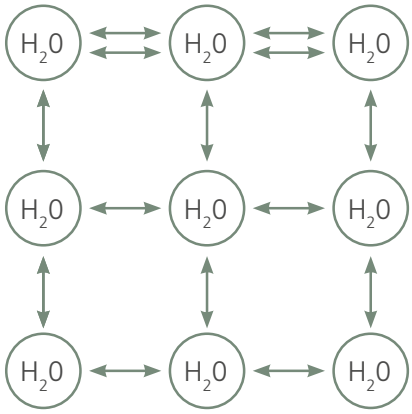


Figure 6 Surface tension – molecules at the surface form stronger bonds

Formality and Academic register

Academic register and style is determined by the scientific community you operate in, your readership or your audience, and choices in language or writing style deemed appropriate by your peers.

For example, when you describe a process orally, you might use phrasal verbs such as "put in or goes up", direct questions "Have you taken into account selectivity?" or fillers like "Well, …Isn't it?".

According to the American Chemistry Society (ACS) style guide (2006), such conventions are not acceptable by chemistry professionals. In fact, one word verbs should replace phrasal verbs e.g. added or declines, nominalisations (nouns) are more frequent than verbs, (e.g. addition, duration, decomposition) positive statements should replace negative ones and indirect questions should replace direct ones (e.g. The reaction rate might be affected by several parameters such as selectivity.)

Listening

Task 15 In pairs, compare the previous description on "States of matter" with the following lecture. Which one is more formal? Why? https://www.youtube.com/watch?v=21CR01rlmv4

Task 16 Listen to the lecture again and find formal alternatives to replace the following concepts.

Solids:

(Audio 2)	*(Audio 1)*
1 Closely packed particles	**1** _____
2 Fixed shape	**2** _____
3 Cannot be squashed	**3** _____
4 Particles cannot move anywhere/Fixed positions	**4** _____
	5 _____

Liquids:

(Audio 2)

1 Can flow

2 No fixed shape

3 Fixed volume

4 Closely packed

(Audio 1)

1 _____

2 _____

3 _____

4 _____

Gases:

(Audio 2)

1 Particles are not closely packed

2 Can be squashed

3 Fill the whole space

4 No fixed shape

5 They are not rigid

(Audio 1)

1 _____

2 _____

3 _____

4 _____

5 _____