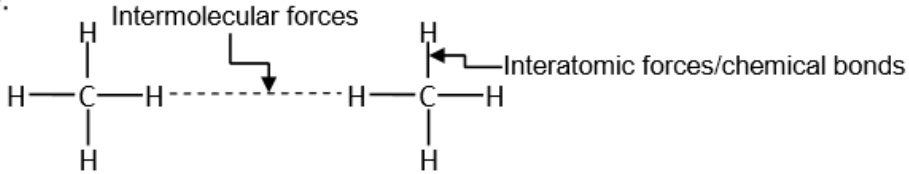
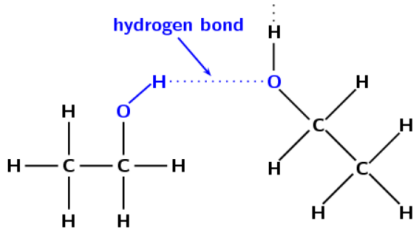
SUBJECT and GRADE	Physical Sciences Grade 12	
TERM 1	*Week 6*	
TOPIC	Organic Chemistry (Physical properties)	
AIMS OF LESSON	The focus of this lesson will be on the following: • For a given example, explain the relationship between physical properties (boiling point, melting point, vapour pressure) and: o Strength of intermolecular forces (Van der Waal's forces), i.e. hydrogen bonds, dipole-dipole forces, induced dipole forces o Type of functional groups o Chain length o Branched chains	
RESOURCES	***Paper based resources***	***Digital resources***
	Learners are referred to the: • Organic Chemistry topic in the textbook or study guides (e.g. Answer Series) that learners will have on hand. • Examination Guideline (page 17) • Mind the Gap Chemistry book (pages 18 -29) • Past NSC Examination papers (refer to Paper 2 question 3)	Refer to the relevant digital resources: • Past NSC Examination papers (Paper 2 refer to question 3) https://wcedonline.westerncape.gov.za/grade-12-question-papers • Telematics https://wcedonline.westercape.gov.za/edumedia/revision-dvds-telematics • Mind the Gap https://wcedonline.westercape.gov.za/mind-gap • HeyScience App for Physical Sciences on Play Store

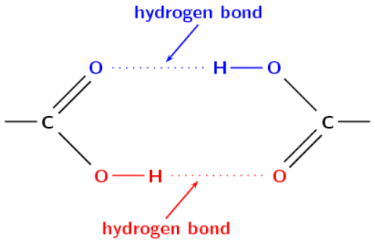
INTRODUCTION	• Each chemical compound has physical properties such as its phase, melting point, boiling point, vapour pressure, viscosity, density and solubility. • These properties are affected by the strength of the intermolecular forces between the molecules in the compounds. When the intermolecular forces between the molecules of a substance are strong: • a lot of energy is required to overcome these intermolecular forces; • the molecules aren't easily separated from one another. Remember from grade 11: As the strength of the intermolecular forces INCREASES: • Less vapour is produced hence vapour pressure above the liquid DECREASES; • Melting and boiling points INCREASE.
CONCEPTS AND SKILLS	**Intermolecular forces and interatomic forces (chemical bonds) (From grade 11)** • The different intermolecular forces (Van der Waal's forces): (i) Induced dipole forces or London forces: Forces between non-polar molecules (ii) Dipole-dipole forces: Forces between two polar molecules (iii) Hydrogen bonding: Forces between molecules in which hydrogen (H) is covalently bonded to nitrogen (N), oxygen (O) or fluorine (F) – a special case of dipole-dipole forces • The following diagram explains the difference between intermolecular forces and interatomic forces (intramolecular forces). Example:  The following table shows the types of intermolecular forces that exist between different organic molecules as well as their relative strengths: **Van der Waals Forces** | ***Hydrogen bonds***

London Forces	***Dipole – dipole forces***	
Very weak Found between non-polar molecules.	Slightly stronger than London forces. Found between slightly polar molecules.	Strongest of the intermolecular forces.
Examples		
Alkanes Alkenes Alkynes	Aldehydes Ketones Esters Haloalkanes (Alkyl halides)	Alcohols Carboxylic acids

- Carboxylic acids have stronger Hydrogen bonds than Alcohols because it is possible for two hydrogen bonds to form between adjacent carboxylic molecules and only one hydrogen bond between adjacent alcohol molecules.



Alcohols



Carboxylic acids

- The relationship between intermolecular forces and molecular size is as follow: For non-polar molecules, the strength of induced dipole forces increases with molecular size.

- The effect of intermolecular forces on boiling point, melting point and vapour pressure is as follows:

Boiling point: The temperature at which the vapour pressure of a substance equals atmospheric pressure.
The stronger the intermolecular forces, the higher the boiling point.

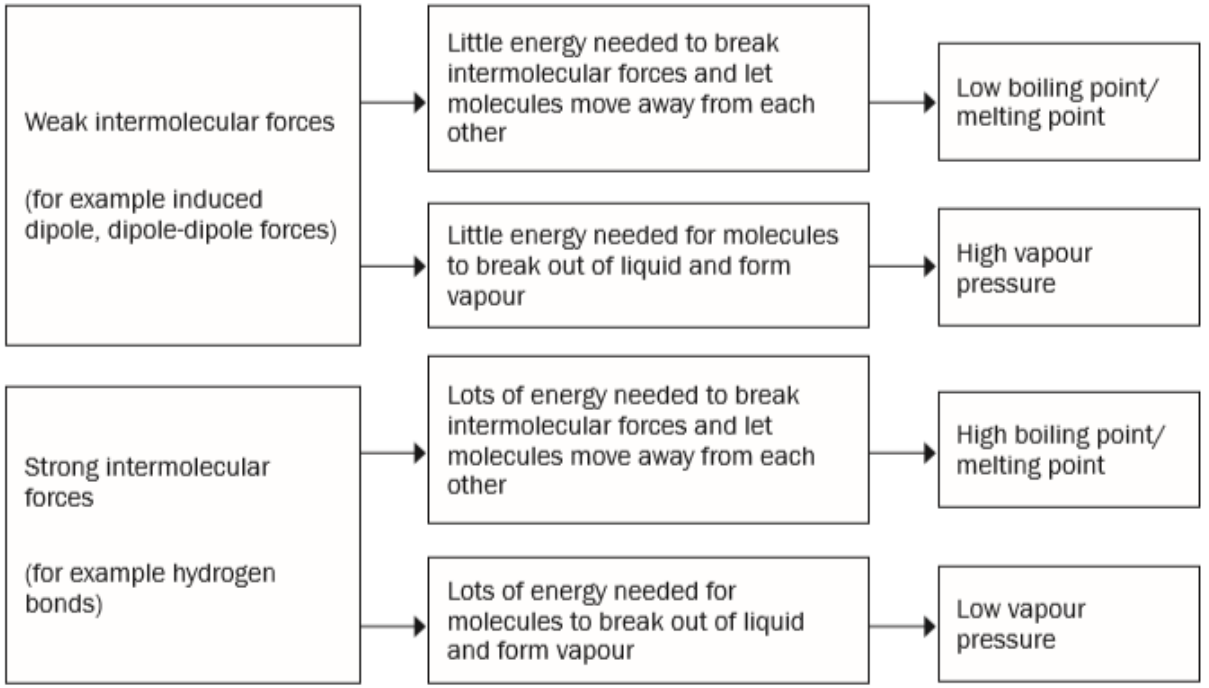
Melting point: The temperature at which the solid and liquid phases of a substance are at equilibrium.
he stronger the intermolecular forces, the higher the melting point.

Vapour pressure: The pressure exerted by a vapour at equilibrium with its liquid in a closed system.
The stronger the intermolecular forces, the lower the vapour pressure.

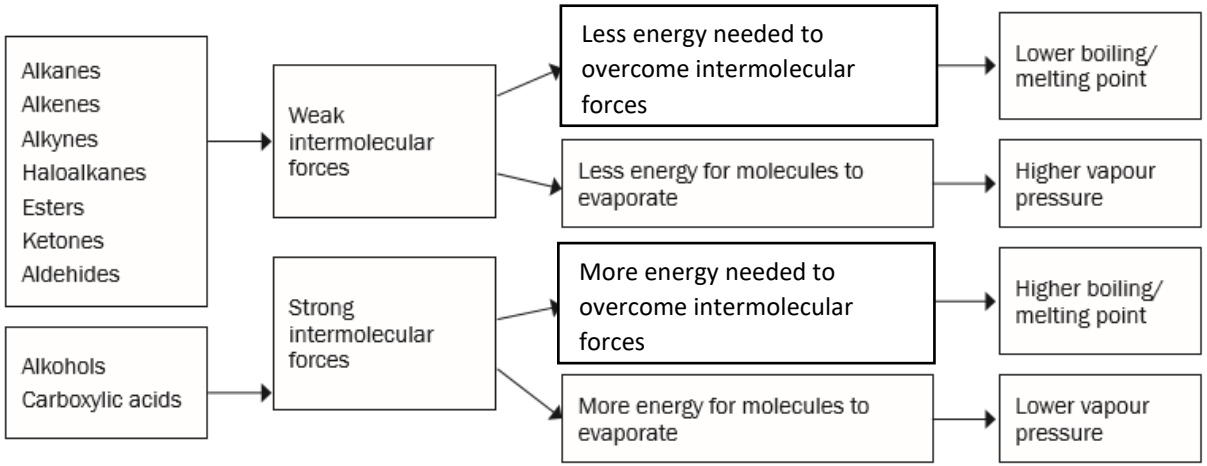
Key points to consider when studying this topic:

In order to determine why the physical properties, differ, you will need to find answers to one or more of the following questions:

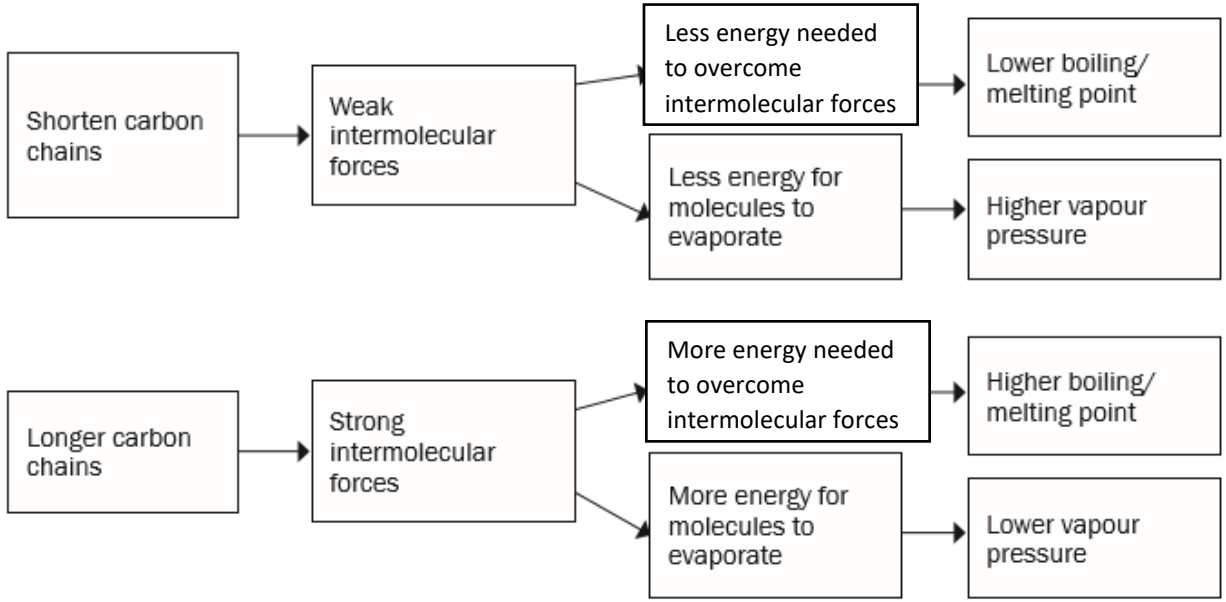
1. What is the influence of the type of intermolecular forces present between the molecules of the organic compound on its physical properties?

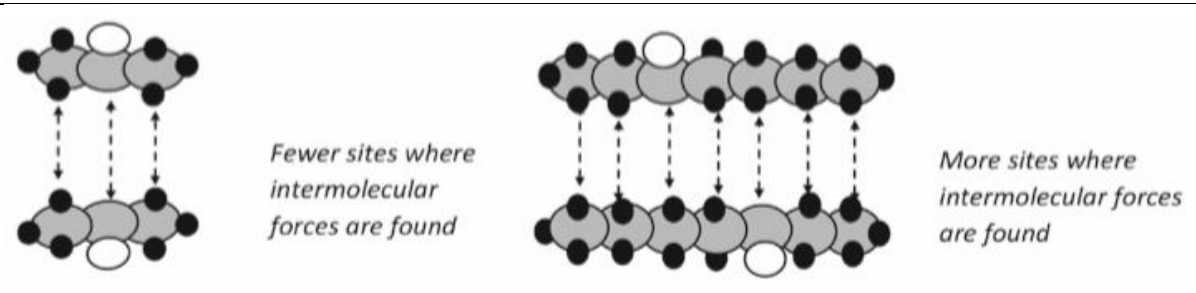


2. What is the influence of the type of functional group that is found in the molecule on its physical properties? In organic compounds where hydroxyl groups (-OH) are present (for example alcohols, carboxylic acids) you will find hydrogen bonds and induced dipole forces. In organic compound where hydroxyl groups are not present (for example alkanes, alkenes, alkynes, halo-alkanes, aldehydes, ketones and esters) you will find induced dipole forces or dipole-dipole forces.

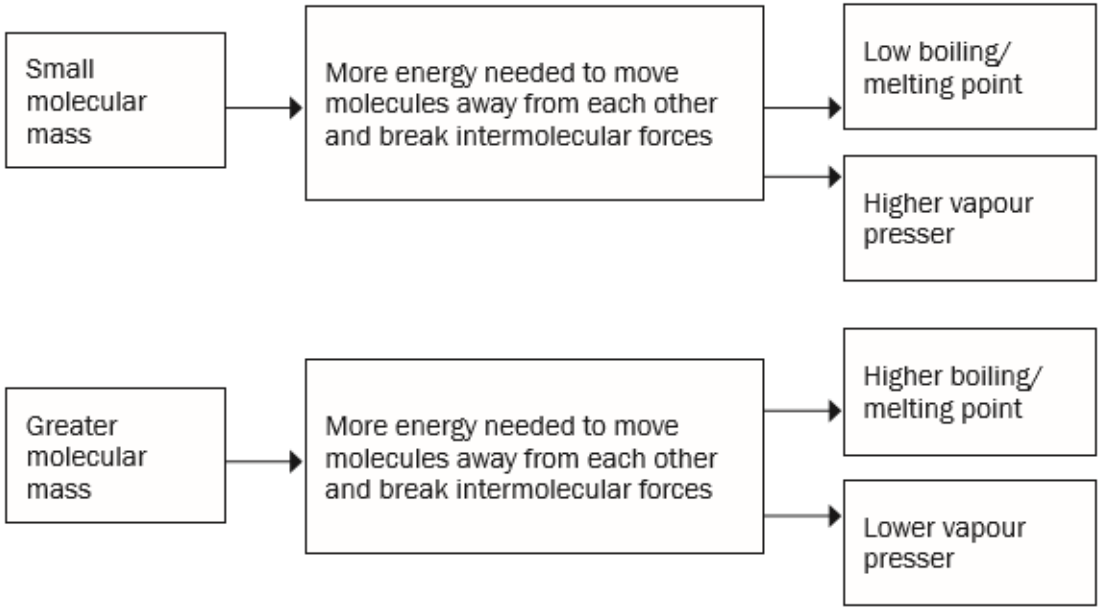


3. What is the influence of the chain length of the molecule on its physical properties? As the length of the carbon chain in the organic compound increases, the number of si, tes where you will find the intermolecular forces will increase. Therefore, the longer the carbon chain, the stronger the intermolecular forces between the molecules.

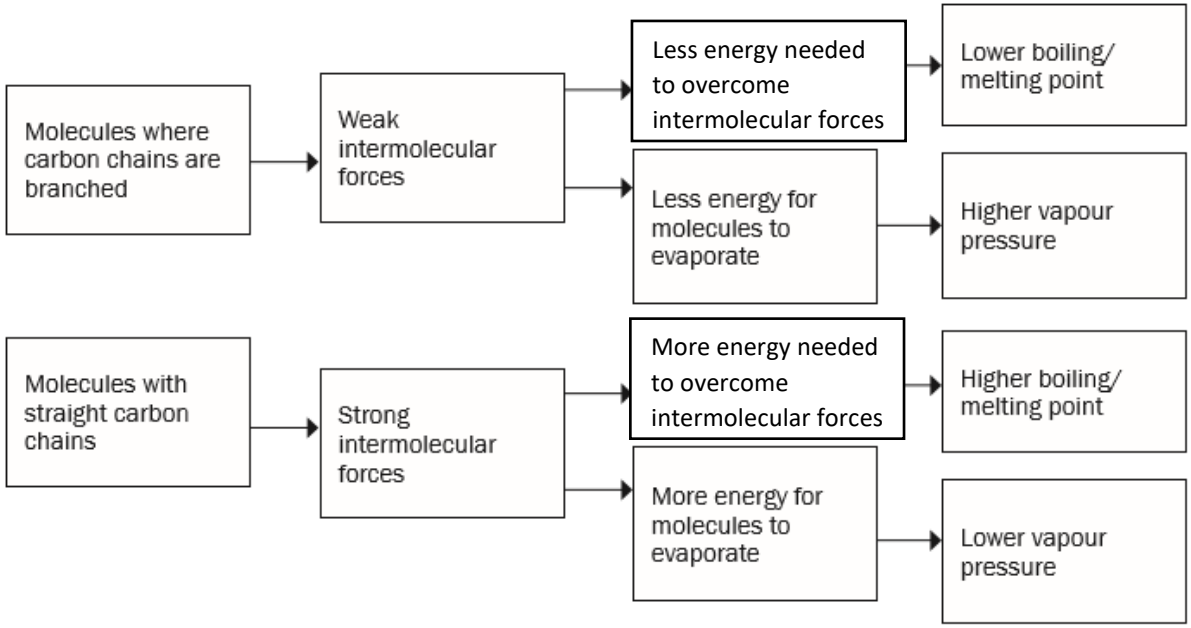


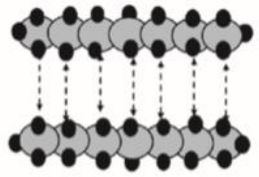


4. What is the influence of the molecular mass of an organic compound on its physical properties?

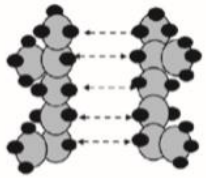


5. What will the influence on the physical properties of an organic compound be if the compound is made up of branched carbon chains? As the number of branches (alkyl groups) increases, the shape of the molecule changes to a more compact, spherical shape with a smaller surface area, resulting in a smaller contact area between the molecules and weaker net Van der Waals forces.





In both substances, the molecules have the same number of carbons



long chain length gives greater surface area over which intermolecular forces can act

short or branched chains give less surface area over which intermolecular forces can act

	Please remember the following: • In the Grade 12 exam you will be asked to explain why the physical properties (melting point, boiling point, vapour pressure) of different organic compounds, differ. • Refer to the TYPE, the STRENGTH of intermolecular forces and ENERGY NEEDED to overcome the intermolecular forces to explain the difference in boiling points, melting points and vapour pressure of organic molecules
ACTIVITIES/ ASSESSMENT	Do the *Organic Chemistry activities/assessment* in your *Physical Sciences textbooks or Study guides.* *Informal assessment activities in Mind the Gap:* • Physical properties and Intermolecular forces: Activity 5 (page 22)
CONSOLIDATION	In this topic we have introduced the Structure and Physical properties (boiling point, melting point, vapour pressure) relationships. Consolidation activities are included at the end of this lesson.
VALUE	Intermolecular forces allow us to determine which substances are likely to dissolve in other substances, and what the melting and boiling points of substances are. Without intermolecular forces holding molecules together we would not exist. Many of the properties of the hydrocarbons are determined by their molecular structure, the bonds between atoms and molecules, and their surface area. The melting points and boiling points of the hydrocarbons increases as their number of carbon atoms increases. The molecular mass of the hydrocarbons determines whether they will be in the gaseous, liquid or solid phase at specific temperatures. The weaker the intermolecular forces between molecules the more volatile and the higher the vapour pressure of that compound.

CONSOLIDATION ACTIVITY

QUESTION 1

1.1 Define the term boiling point. (2)

1.2 What is the relationship between strength of intermolecular forces and boiling point? (1)

The relationship between strength of intermolecular forces and boiling point is investigated using four organic compounds from different homologous series. The compounds and their boiling points are given in the table below.

	COMPOUND	BOILING POINT (°C)
A	Propane	-42
B	Propan-2-one	56
C	Propan-1-ol	97
D	Propanoic acid	141

1.3 Refer to the TYPE and the STRENGTH of intermolecular forces to explain the difference in boiling points between:

1.3.1 Compounds A and B (3)

1.3.2 Compounds C and D (3)

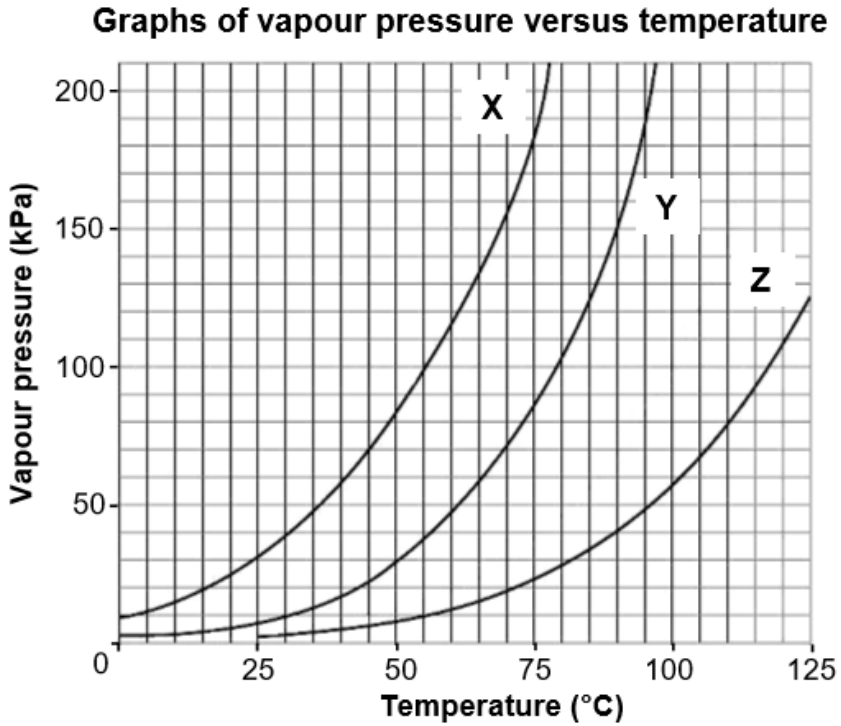
1.4 Is compound B a GAS or a LIQUID at room temperature? (1)

[10]

QUESTION 2

Study the vapour pressure versus temperature graphs for three organic compounds, X, Y and Z, below which belong to different homologous series.

Atmospheric pressure is 100 kPa.



2.1 Write down the vapour pressure of compound Y at 90 °C. (1)

2.2 The graphs can be used to determine the boiling points of the three compounds.

2.2.1 Define boiling point. (2)

2.2.2 Determine the boiling point of compound X. (1)

2.3 The homologous series to which the three compounds of similar molecular masses belong, were identified in random order as: alcohol; carboxylic acid; ketone

2.3.1 Which compound (X, Y or Z) is the carboxylic acid? (1)

2.3.2 Explain the answer to QUESTION 2.3.1 by referring to the type of intermolecular forces in compounds of each of the homologous series above. (4)

2.3.3 Compound X has three carbon atoms per molecule. Write down the IUPAC name of compound X. (1)

[10]

CONSOLIDATION ACTIVITY MARKING GUIDELINE

QUESTION 1

1.1 Temperature✓ at which the vapour pressure equals atmospheric pressure. ✓ (2)

1.2 The stronger the intermolecular forces, the higher the boiling point. / The boiling point is proportional to the strength of intermolecular forces. ✓ (1)

1.3.1 • In A/propane/alkanes: London forces/dispersion forces/induced dipole forces ✓

• In B/ propan-2-one/ketones: dipole-dipole forces ✓ in addition to London forces/dispersion forces/induced dipole forces

• Intermolecular forces in A are weaker ✓than in B. /Intermolecular forces in B are stronger ✓ than in A. /London forces are weaker than dipole-dipole forces. (3)

1.3.2 • Both C and D: hydrogen bonding ✓

• D has two/more sites for hydrogen bonding. /D forms dimers. /D is more polar. /C has one/less sites for hydrogen bonding. ✓

• D has stronger intermolecular forces than C. /C has weaker intermolecular forces than D. ✓ (3)

1.4 Liquid ✓ (1)

[10]

QUESTION 2

2.1 150 kPa✓ (1)

2.2.1 Die temperatuur waar die dampdruk gelyk is aan atmosferiese/eksterne druk. ✓✓ (2)

2.2.2 55 °C ✓ (1)

2.3.1 Z ✓ (1)

2.3.2 Carboxylic acids have, in addition to London forces and dipole-dipole forces, two sites for hydrogen bonding between molecules. ✓
OR Carboxylic acids can form dimers due to strong hydrogen bonding between molecules. ✓

Alcohols have, in addition to London forces and dipole-dipole forces, one site for hydrogen bonding between molecules. ✓ Ketones has, in addition to London forces, dipole-dipole forces between molecules. ✓

Intermolecular forces in carboxylic acids is the strongest. /Most energy needed to overcome/break intermolecular forces in ethanoic acid. ✓ (4)

2.3.3 Propanone ✓

OR Propan-2-one

OR 2-propanone (1)

[10]