Unit Preparation Booklet

C5.1 Carbon Chemistry

Teacher name:

Science Mastery

Ark Curriculum+

Contents

Steps to Success

		What?	Why?	Who?	Page #
Preparing to teach	**1**	☐ Print this booklet or save a copy in a personal folder	To allow for engagement during planning and co-planning	*All teachers*	
	2	☐ Engage with the unit preparation checklist	To prepare for delivering the sequence of lessons	*All teachers*	4
	3	☐ Read the scope and sequence for the unit	To review the scope and sequence of the unit	*All teachers*	5
	4	☐ Complete the pre-unit quiz reflections task after administering to class	To plan how to remedy prior knowledge gaps	*New to teaching the unit only*	10
	6	☐ Complete the Mastery Quiz and exam-style questions activity	To learn/revisit the key assessment objectives of the unit	*New to teaching the unit only*	11-22
	7	☐ Complete the misconception activities	To develop a strong understanding of the most common misconceptions for the unit and how to address them	*New to teaching the unit only*	23-24
Delivering the unit	**8**	☐ Use the lesson-by-lesson objectives to monitor progression through the unit	To maintain a record of completion and to recognise what needs to be reviewed after each lesson	*Novice teachers only*	25-41
Utilise other features of the booklet	**9**	☐ Complete the A-level/ GCSE activity	To develop an understanding of where the unit can lead	*Non A-level/GCSE specialists*	42
	10	☐ Engage in the keywords for the unit	To identify the correct definitions for keywords throughout the unit	*Novice teachers only*	43-44

Unit preparation checklist

Resources can and should be tailored to meet your pupils' needs. We have aimed to do as much resourcing as possible so that teachers' time can be spent on co-planning and preparation; however, they are only ready for your pupils once you have decided how to make use of them.

Here is a suggested checklist:

Locate:

- ☐ **Find** the unit resources using MyMastery or SharePoint

Engage:

- ☐ Work through the preparation booklet. Complete the pre-unit quiz, mastery quiz and exam-style questions yourself and reflect (all enclosed)
- ☐ Set your class the **pre-unit quiz** (in advance of the unit).
- ☐ Note which topics are **areas of weakness** for the class (space available in this booklet or on the planning pro-forma)
- ☐ **Decide** which topics you will re-visit 'in advance' and which to tackle during the unit (space available in this booklet or on the planning pro-forma)
- ☐ Identify where in the sequence of learning there are opportunities for embedding **guided reading**
- ☐ Use the **lesson planning guidance** to develop a grasp of the purpose of each lesson element

Adapt:

- ☐ Consider key timings for each lesson. Identify which lessons may need to be adapted to account for the length of your lessons or ability level of your class
- ☐ Identify what could be used as **homework** activities to support in-class learning in line with school policy
- ☐ Review the resources ahead of each lesson and ensure you are clear on the objectives of each lesson
- ☐ **Select** appropriate activities for each lesson from the selection within each lesson folder/on the slide deck
- ☐ **Administer** exit tickets and use outcomes of this to plan 'fix-it' tasks to tackle misunderstanding or misconception.
- ☐ Set the **mastery quiz** for your class. Use the information to plan a suitable re-teach lesson and further response, using the resources available.

Scope and Sequence

Scope

This unit covers the topic of organic chemistry, including crude oil and hydrocarbons and the different homologous series'. In this unit students will look at the uses of different hydrocarbons, how they are obtained and how cracking is used to meet demand, as well as how crude oil is used to make polymers. The chemistry only content includes the additional homologous series' and the production of ethanol, esterification and polymerisation.

Sequence

This unit begins with a recap of key learning from C4.1 on covalent bonding and structure. Here, students are reminded both of how carbon-carbon and carbon-hydrogen bonds occur and (importantly) how the bonding and structure of molecules results in different properties. From here, students are introduced to crude oil and hydrocarbons. This lesson forms the basis of the rest of this unit as students will be exploring different types of hydrocarbon compounds, each of which can be traced back to crude oil. In this lesson, students will learn what a hydrocarbon is, and are introduced to their first homologous series, alkanes, The careful introduction of alkanes and the naming of these, if effective, will set students up to understanding the naming and structure of the other homologous series.

As crude oil appears early on, the next lesson delves into the process of fractional distillation, as this is the process that allows us to obtain all the various fractions that are the basis of much of the carbon chemistry that students learn about. Learning about this early in the unit is important, because it is here that students learn about the relationship between hydrocarbon chain length and boiling point, something which allows students to understand the idea of a good and poor fuel, and all of the properties associated with these. The discussion of good and poor fuels is continued in lesson 4, with a deeper exploration of the combustion of hydrocarbons.

From here, students are introduced to alkenes and cracking. This is a natural progression from learning about fractional distillation, as students now know about which fractions are in most demand, and so the process of cracking will make more sense to them. Students here build on their new knowledge of alkanes to understand their next homologous series: alkenes. After this, chemistry students are introduced to alcohols, and here they will learn about different ways to produce ethanol. This is followed by carboxylic acids and esters, in this order because each depends on the previous one to understand. Each time, the principals of a homologous series are reiterated, and students are gradually getting to know the patterns and formulae for each one. Finally the unit ends by learning about polymers, polymerisation and naturally occurring polymers. This is partly revisiting learning from C4.1 where students were introduced to polymers in the context of covalent bonding, and revisits biology topics where they learn about naturally occurring polymers in more detail. The new learning here in this unit builds on students' learning about hydrocarbons, so that students are using their knowledge of functional groups to describe condensation and addition polymerisation.

A full set of knowledge objectives for this unit can be found as **Appendix 5.**

1	2	3	4
Prior Knowledge Review: Covalent Bonding and Structure	Crude Oil and Hydrocarbons	Fractional Distillation	Combustion of Hydrocarbons
5	**6**	**7**	**8**
Cracking	Taking it Further: Alkenes	Taking it Further: Alcohols	Taking it Further: Producing Ethanol by Fermentation
9	**10**	**11**	**12**
Taking it Further: Producing Ethanol from Ethene	Taking it Further: Carboxylic Acids	Taking it Further: Esters	Prior Knowledge Review: Polymers
13	**14**	**15**	**16**
Taking it Further: Addition Polymerisation	Taking it Further (HT): Condensation Polymerisation	Taking it Further: Naturally Occurring Polymers	Feedback Lesson

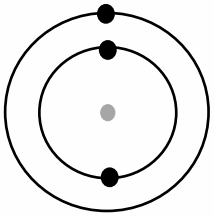
TASKS:

New teachers: Organise the lesson titles into those you feel most to least confident about *Experienced teachers:* Reflect on prior experience of teaching this unit. Which lessons have gone well? Which would you like to target for improvement this year?

Pre-unit quiz

1. The atomic structure of elements relates to their position on the Periodic Table.

   In which group of the Periodic Table would you find the element represented by this electronic configuration? [1]



   Tick (✓) **one** box.

   A. Group 2 ☐

   B. Group 3 ☐

   C. Group 1 ☐

2. Which is the correct definition of a compound?

   Tick (✓) **one** box. [1]

   A. Two or more elements mixed together ☐

   B. Two or more elements chemically bonded together ☐

   C. A group of non-metal atoms bonded together ☐

3. Which is the correct definition of a molecule?

   Tick (✓) **one** box. [1]

   A. A group of metals atoms bonded together ☐

   B. A group of metal and non-metal atoms bonded together ☐

   C. A group of non-metal atoms bonded together ☐

4. Which type of bonding would be found in a molecule of oxygen?

Tick (✓) **one** box. [1]

A. Covalent ☐

B. Ionic ☐

C. There would be no bonding ☐

5. Which type of bonding would be found in sodium chloride?

Tick (✓) **one** box. [1]

A. Covalent ☐

B. Ionic ☐

C. Metallic ☐

6. Which statement is true of covalent substances?

Tick (✓) **one** box. [1]

A. They contain non-metal atoms ☐

B. They contain metal atoms ☐

C. They contain metal and non-metal atoms ☐

7. What type of atoms make up both diamond and graphite?

Tick (✓) **one** boxes. [1]

A. oxygen ☐

B. hydrogen ☐

C. carbon ☐

D. copper ☐

8. Choose the correct electronic configuration of a carbon atom.

The atomic number of carbon is 6. [1]

Tick (✓) **one** box.

A. 2,4 ☐

B. 2,2,2 ☐

C. 2,8 ☐

9. Choose the best explanation for why noble gases are unreactive. [1]

Tick (✓) **one** box.

A. They all have 8 electrons in their outer shell ☐

B. They have a stable electron arrangement ☐

C. They are neutral because they have equal numbers of protons and electrons ☐

10. Define 'polymer'.

Tick (✓) **one** box. [1]

A. A polymer is a type of plastic ☐

B. A polymer is a long chain molecule made up of many units ☐

C. A polymer is a type of plastic that melts when heated ☐

Pre-unit quiz reflections

To be completed once you have reviewed your pupils' response to the pre-unit quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout the unit?

Other notes

Mastery Quiz

TASK: Below is the mastery quiz available for your pupils to sit at the end of the unit. Complete yourself and consider the key misconceptions this quiz aims to address. See **Appendix 2** for the mark scheme.

Section A

1. Choose the correct word to complete the sentence:

   Crude oil is formed by the decomposition of _____.

   Tick (✓) **one** box. [1]

   A. Plankton ☐

   B. Fish ☐

   C. Rocks ☐

2. Choose the correct word to complete the sentence:

   Crude oil is a _____ of different substances.

   Tick (✓) **one** box. [1]

   A. Compound ☐

   B. Mixture ☐

   C. Molecule ☐

3. A group of hydrocarbons found in crude oil are the alkanes. What is the name of the alkane that contains 3 carbon atoms?

   Tick (✓) **one** box.[1]

   A. Ethane ☐

   B. Propane ☐

   C. Butane ☐

4. The general formula for the alkanes is C_nH_{2n+2}. How many hydrogen

atoms would there be in a molecule of an alkane with 14 carbon atoms?

Tick (✓) **one** box. [1]

A. 28 ☐

B. 30 ☐

C. 32 ☐

5. Which type of bonding is found in the alkanes?

Tick (✓) **one** box. [1]

A. Covalent ☐

B. Ionic ☐

C. Metallic ☐

6. Decane is an alkane that is cracked to produce two products, as shown by the reaction below.

$C_{10}H_{22} \rightarrow$ _____ + C_2H_4

What is the formula of the other product?

Tick (✓) **one** box. [1]

A. $C_{12}H_{26}$ ☐

B. C_8H_{16} ☐

C. C_8H_{18} ☐

7. Which statement best explains why large hydrocarbons are cracked?

Tick (✓) **one** box. [1]

A. There is greater demand for shorter hydrocarbon chains ☐

B. Large hydrocarbon chains have low boiling points so are easy to break down ☐

C. To make equal numbers of long and short chain hydrocarbons ☐

8. One of the products of the cracking of decane is C_2H_4, which is an alkene. What test and result would indicate the presence of an alkene?

Tick (✓) **one** box. [1]

A. Limewater would turn cloudy ☐

B. Limewater would turn colourless ☐

C. Bromine water would turn cloudy ☐

D. Bromine water would turn colourless ☐

9. Fractional distillation is used to separate the different substances found in crude oil. There are three stages involved in this process:

Stage X: Hydrocarbons evaporate

Stage Y: Crude oil is heated

Stage Z: Vapours condense

Which option shows the correct order of these stages?

Tick (✓) **one** box. [1]

A. X, Y, Z ☐

B. Z, Y, X ☐

C. Y, X, Z ☐

10. Choose the correct option to complete the sentence:

Fractional distillation separates substances based on their _____.

Tick (✓) **one** box. [1]

A. Boiling points ☐

B. Melting points ☐

C. Temperature ☐

11. Choose the products of the complete combustion of propane.

Tick (✓) **one** box. [1]

A. Water and oxygen ☐

B. Water and carbon dioxide ☐

C. Oxygen and carbon dioxide ☐

12. Incomplete combustion of propane also produces another product, carbon monoxide. Which explains why combustion may be incomplete?

Tick (✓) **one** box. [1]

A. There is not enough propane ☐

B. There is not enough oxygen ☐

C. There is more oxygen than propane ☐

13. What type of reaction is the combustion of propane?

Tick (✓) **one** box. [1]

A. Exothermic, as it transfers energy to the surroundings ☐

B. Exothermic, as it takes in energy from the surroundings ☐

C. Endothermic, as it transfers energy to the surroundings ☐

D. Endothermic, as it takes in energy from the surroundings ☐

14. Which monomer is used to produce poly(ethene)?

Tick (✓) **one** box. [1]

A. Ethane ☐

B. Ethene ☐

C. Alkene ☐

15. Petrol used in fuels should be treated to remove sulfur. Which correctly explains why?

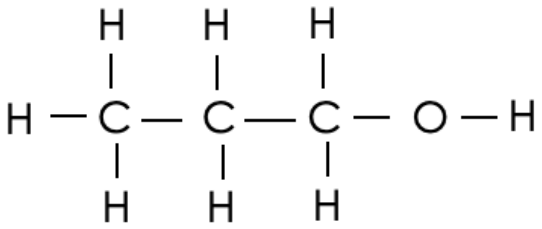
Tick (✓) **one** box. [1]

A. It would cause incomplete combustion ☐

B. It would burn to produce sulfur dioxide, leading to acid rain ☐

C. It would burn to produce carbon dioxide, leading to global warming ☐

CHEMISTRY ONLY



16. The structural formula above shows an organic compound. What is the name of this compound?
Tick (✓) **one** box. [1]

A. Propane ☐

B. Propene ☐

C. Propanol ☐

17. What is the functional group for the homologous series that the compound above belongs to?
Tick (✓) **one** box. [1]

A. C-H ☐

B. C-O ☐

C. O-H ☐

18. Ethanol reacts with ethanoic acid to form ethyl ethanoate. What type of compound is ethyl ethanoate?
Tick (✓) **one** box. [1]

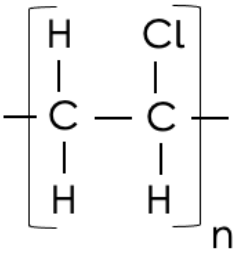
A. A carboxylic acid ☐

B. An ester ☐

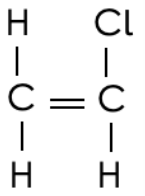
C. A polymer ☐

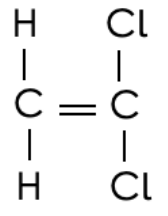
19. The figure below shows the displayed structural formula of

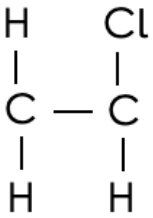
poly(chloroethene). Which monomer would have been used to make poly(chloroethene)?



Tick (✓) **one** box. [1]

A.  ☐

B.  ☐

C.  ☐

20. What type of polymerisation would poly(chloroethene) have formed from?
Tick (✓) **one** box. [1]

A. Addition ☐

B. Condensation ☐

C. Esterification ☐

Section B

1. Butane is an alkane.
   a. Complete the structural formula for butane. [2]

C - C - C - C

   b. Give the chemical formula for butane. [1]

_____

2. The table below shows the melting points and boiling points of methane (CH_4) and hexane (C_6H_{14}).

	Melting Point (°C)	**Boiling Point (°C)**
Methane	-183	-162
Hexane	-95	69

   a. Identify the state of matter that each would be at room temperature (20 °C). [2]

   Methane: _____

   Hexane: _____

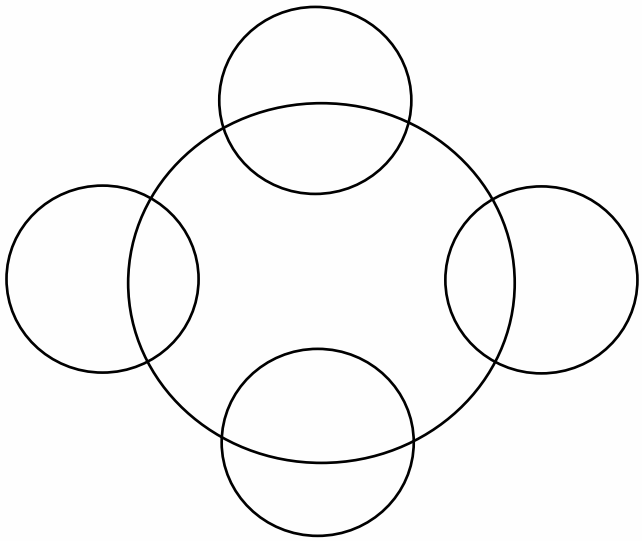
   b. Compare the structure and properties of methane and hexane. [4]

_____
_____
_____
_____
_____
_____

   c. Explain the trend in the boiling points of the alkanes. [2]

_____
_____
_____
_____

d. Complete the dot and cross diagram to show the bonding in methane (CH_4). [2]



3. Carboxylic acids and alcohols are homologous series which contain different functional groups.
   a. State the formula of the functional group found in carboxylic acids. [1]

_____

   b. Ethanol is an alcohol. Give one use of ethanol. [1]

_____

   c. Carboxylic acids can react with alcohols. Complete the general equation for these reactions: [2]

      Alcohol + carboxylic acid → _____ + _____

   d. Ethanol can be made in two different ways:
      - fermentation
      - hydration of ethene with steam

   The table below gives some information about each process.

Feature	Process	
	Fermentation	**Hydration**
Raw material	Sugar	Crude oil
Relative energy usage	Low	High
Relative rate of reaction	Low	High
Purity of ethanol product	18%	95%

Evaluate which method of producing ethanol should be used. [6]

Mastery quiz reflections

Which aspects of this unit are likely to be the most challenging to teach?	
What are your pupils likely to find most challenging and why?	
Challenging.....	Because....
E.g. The number of new keywords	*They are abstract words that aren't used in other areas of science*
How can you pre-empt some of the key misconceptions the mastery quiz aims to identify?	
Misconception	**How to avoid**

Exam-style questions

TASK: Using Exampro (or the software used by your exam board), look through the typical exam-style questions for this topic. These sorts of questions are posed throughout the unit and pupils should be prepared to answer similar questions in the end-of-year assessments.

Suggested questions to guide this process:

How is knowledge from this unit typically assessed? What are the most common questions?
Which question types are the most challenging?
What general trends can you spot in the typical errors pupils make (from examiner reports/notes)?
How could you help prepare your students for answering these types of questions?

Common mistakes, errors and misconceptions

How would you tackle the following common mistakes, errors and misconceptions by pupils?

TASK: Consider why each of the following typically seen statements is a mistake/misconception. What possible approaches can you plan to pre-empt and respond to this? Which lessons do these correlate to?

CHALLENGE: Cover the middle column and explain yourself why each is a mistake.

Mistake	**Reason why it's a mistake**	**Possible approaches to pre-empt and respond?**
Crude oil is a compound	Crude oil is a mixture of compounds	
Hydrocarbons are mixtures of carbon and hydrogen	Hydrocarbons are compounds, a mixture of which make up crude oil	
Hydrocarbons contain water and carbon	The prefix hydro- refers to hydrogen not water	
Methene is the first alkene	Alkenes require a C=C double bond but the prefix meth- means only one C, so this is not possible	
Long chain hydrocarbons are better fuels because they are larger molecules	Longer molecules are less flammable so they are not as useful as fuels	
Cracking is a physical process	Cracking is a chemical reaction as new products are formed	
Fractional distillation is a chemical reaction	Fractional distillation is a physical process, as it separates a mixture into its different parts but no new substances are made	
During fractional distillation, crude oil evaporates at the same temperature	Many students struggle with the temperature gradient of a fractionating column. The fractions evaporate then condense at their boiling points	
Carbon and hydrogen atoms are held together by strong intermolecular forces in hydrocarbons	Within hydrocarbons there are strong covalent bonds	
Hydrocarbons contain strong covalent bonds between molecules	Intermolecular forces exist between molecules	
During fractional distillation, it is the covalent bonds of the hydrocarbons that are broken	During fractional distillation, intermolecular forces are overcome	

Planning for the misconceptions

Misconception: Cracking is a physical process/Fractional distillation is a chemical reaction
Students often confuse the process of fractional distillation and cracking. For them to understand the process of each, they need to be very clear with definitions of compound and mixture, as well as the fact that a new substance is made in a chemical reaction. A big part of the confusion comes from the fact that heat is involved in both, so students often assume they are doing the same thing. It is useful to explicitly compare the two processes.
Supporting pupil understanding
The end point to work towards is getting students to be able to write a correct and detailed answer to the question: 'Explain how demand for short chain hydrocarbons is met through fractional distillation and cracking'. They are taught in sequence in this unit so that students can follow the process chronologically. - First crude oil is separated into fraction: *Why is crude oil described as a mixture? What does it contain?* **It contains different types of compound (different hydrocarbons) that are not chemically bonded (to each other).** *What methods of separation can be used to separate a mixture? When would each be used?* **Filtration – to separate a solid from a liquid** **Evaporation – to separate two liquids based on their boiling points but one would escape** **Distillation – to separate liquids based on their boiling points, where they will condense.** *Are these physical or chemical processes?* **Physical processes – no new products have been made, parts of the mixture have just been separated** So now we have each of our different fractions. Some of the larger fractions are not very flammable are so not as useful as fuels. We can use cracking to break these up into smaller molecules. Using a specific hydrocarbon formula (e.g. C24H50): this can be broken up into a shorter alkane and an alkene. *Is this a chemical reaction or a physical process? Has a new product been made?* **Yes – this is a chemical reaction.**

Misconception: Crude oil is a compound
Students often think that crude oil itself is a hydrocarbon, rather than a mixture of hydrocarbons.
Supporting pupil understanding
Reminding/quzzing students on the definition of a mixture is important at the start of this. Showing students a different mixture (e.g. sugar water, tea etc) can be useful for them to see that although it may look like one substance, it contains different things.

Unit objectives: knowledge, skills and concepts

As you teach the lessons, track here the objectives you meet.

TKT = to know that TBAT = to be able to

Critical: it is critical that all pupils become proficient; future learning will be very challenging for them if they do not and it is likely they will not come across this content again. These are priority objectives for reteaching, revision, and intervention. Before moving on, discuss a strategy with your HOD if some pupils are not making progress with these objectives.
Core: it is important for all pupils to learn this, and it will be essential for success at GCSE. However, it will not impede them in other units if they are not (yet) proficient in it as they are likely to revisit it again in subsequent units.
Stretch: pupils should have the opportunity to be work on this aspect of science. This content is crucial for pupils to achieve the highest GCSE grades and to succeed at A-level.
Key skill: pupils should have the opportunity to develop this key skill as part of this unit.

Separate Science only objectives will be underlined.
Higher tier only objectives will be in italics.

Lesson 1: Prior Knowledge Review

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT identify different types of bonding from chemical formulae	Identify the bonding in H_2O. Identify the bonding in H_2. Identify the bonding in NH_3. Identify the bonding in Na_2O. Identify the bonding is CaO. Identify the bonding in KCl.
TBAT describe what happens when a covalent bond is formed	Describe how a covalent bond is formed Explain why atoms form covalent bonds
TBAT use diagrams to show covalent bonding	Draw a dot and cross diagram to show the bonding in a molecule of water Draw a dot and cross diagram to show the bonding in a molecule of ammonia Draw a dot and cross diagram to show the bonding in a molecule of oxygen
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 2: Crude Oil and Hydrocarbons

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT describe where crude oil is found and how it was formed	Describe where crude oil is found. Describe how crude oil was made. What is crude oil formed from the ancient biomass of? What is crude oil?
TBAT identify alkanes from their chemical formulae	Name the alkane that contains two carbon atoms. Identify the alkane with the formula C_4H_{10}.
TBAT Use the general formula of alkanes to determine the number of atoms in a molecule	State the general formula of the alkanes. Determine how many hydrogen atoms would be in a molecule of an alkane that contains 6 carbon atoms. Determine how many hydrogen atoms would be in a molecule of an alkane that contains 24 hydrogen atoms.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 3: Fractional Distillation

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Describe uses of different fractions of crude oil	State the different fractions found in crude oil. Give a use of petrol. Give a use of liquefied petroleum gases. Give a use of heavy fuel oil.
TBAT Describe how crude oil is separated by fractional distillation	Explain what is meant by a crude oil fraction. Explain why crude oil is a mixture. Describe how crude oil is separated into fractions by fractional distillation. What property is used to separate crude oil into fractions?
TBAT Describe and explain trends in the properties of hydrocarbons	Describe the relationship between boiling point and length of hydrocarbon chain. Explain this relationship. Describe the relationship between flammability and length of hydrocarbon chain. Describe the relationship between viscosity and length of hydrocarbon chain.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 4: Combustion of Hydrocarbons

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT State the general equation for the combustion of alkanes	Name the products of the combustion of alkanes. Identify what alkanes react with during combustion. Write a word equation for the combustion of propane. Balance a symbol equation for the combustion of propane.
TBAT Describe the advantages and disadvantages of the combustion of hydrocarbons	State the products of combustion of hydrocarbons. Explain why producing carbon dioxide is a problem. Explain why crude oil is a non-renewable resource. Describe some advantages of using hydrocarbons as fuels.
TBAT Explain the difference between complete and incomplete combustion	Explain what is meant by incomplete combustion. Explain when incomplete combustion takes place. Compare the products of complete and incomplete combustion of alkanes.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 5: Cracking

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Determine the formulae of compounds produced from cracking	$C_{12}H_{26}$ is cracked to produce C_2H_4 and an alkane. Determine the formula of the alkane. Describe the products of a cracking reaction.
TBAT Explain why cracking is useful	Explain what is meant by supply and demand. Explain why demand for short chain alkanes is higher than for longer chain alkanes. Explain how cracking can be used to meet demand.
TBAT Explain how bromine water can be used to distinguish between alkanes and alkenes	Describe the result when bromine water is added to an alkane. Describe the result when bromine water is added to an alkene. Explain the difference between saturated and unsaturated compounds.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 6: Taking it Further: Alkenes

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT State the general formula of the alkenes	Name the first four alkenes. State the functional group of alkenes. State the general formula of alkenes.
TBAT Use chemical formulae to determine the numbers of atoms in molecules.	Name the alkene that contains three carbon atoms. Identify the alkene with the formula C_5H_{10}. Determine how many hydrogen atoms would be in a molecule of an alkene that contains 6 carbon atoms. Determine how many hydrogen atoms would be in a molecule of an alkene that contains 24 hydrogen atoms.
TBAT Describe chemical reactions of the alkenes	Write a word equation for the reaction between ethene and hydrogen. Write a word equation for the reaction between propene and chlorine. Explain why alkenes are able to undergo addition reactions.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 7: Taking it Further: Alcohols

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Draw structural formulae for alcohols	Draw the structural formula for propanol. Draw the structural formula for ethanol.
TBAT Describe uses of alcohols	Give a use of methanol. Give a use of ethanol. Give a use of propanol.
TBAT Describe chemical reactions of alcohols	Write a word equation for the combustion of propanol. Describe the reaction between ethanol and sodium.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 8: Taking it Further: Producing Ethanol by Fermentation

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT State the equation for the production of ethanol through fermentation	Describe what happens during fermentation. State the equation for fermentation. Name the reactant needed for fermentation.
TBAT Describe the conditions required for fermentation	Describe the conditions needed for fermentation. Explain why fermentation must take place in the absence of oxygen. Describe the role of yeast in fermentation.
TBAT Describe the advantages and disadvantages of producing ethanol by fermentation	Describe the advantages of producing ethanol by fermentation. Describe the disadvantages of producing ethanol by fermentation.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 9: Taking it Further: Producing Ethanol from Ethene

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Describe how ethanol can be made from ethene	Describe what happens during hydration of ethene. State the equation for hydration of ethene.
TBAT Describe the conditions required for hydration of ethene	Describe the conditions needed for hydration. Explain the role of the catalyst. State the temperature and pressure required for hydration of ethene.
TBAT Describe the advantages and disadvantages of different methods of ethanol production.	Describe the advantages of producing ethanol by fermentation. Describe the disadvantages of producing ethanol by fermentation. Describe the advantages of producing ethanol from ethene. Describe the disadvantages of producing ethanol from ethene. Evaluate the different methods of producing ethanol.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 10: Taking it Further: Carboxylic Acids

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Identify the functional group found in carboxylic acids	Name the functional group in the carboxylic acids. State the formula of the functional group. Explain what is meant by a functional group.
TBAT Draw structural formulae of carboxylic acids	Draw the structural formula for methanoic acid. Draw the structural formula for butanoic acid.
TBAT Write chemical equations for reactions of carboxylic acids	Describe the properties of acids. Write general equations for the reactions between a carboxylic acid and: - a metal - a base - an alkali - a metal carbonate
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 11: Taking it Further: Esters

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Describe how esters are formed	Name the two types of compound that react to form esters. Give the functional group found in esters
TBAT State the general equation for the formation of esters	Write the general equation to show how an ester is formed. Name the other product that is formed when an ester is made. Write a word equation to show how ethyl ethanoate is formed.
TBAT Describe uses of esters	Give a use of esters. Explain why esters are used in perfumes.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 12: Polymers

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Define a polymer	Define a polymer Define a monomer Identify whether a given compound is a monomer or polymer
TBAT Explain the difference between thermosoftening and thermosetting polymers	Define a thermosoftening polymer. Define a thermosetting polymer. Explain the difference between thermosoftening and thermosetting polymers.
TBAT Explain how the properties of a polymer make it suited to a function	Explain why thermosoftening polymers are used in plastic water bottles. Explain why thermosetting polymers are used as pan handles.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 13: Taking it Further: Addition Polymerisation

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Identify monomers used to make given polymers	Name the monomer used to make poly(ethene). Name the monomer used to make poly(propene). Name the monomer used to make poly(vinylchloride). Determine the formula of a monomer from structural formula of the polymer. Determine the formula of a polymer from structural formula of the monomer.
TBAT Describe the process of addition polymerisation	Describe what happens during addition polymerisation. Explain why no other products are formed. Explain why monomers must contain a double bond for addition polymerisation to take place.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 14: Taking it Further: Condensation Polymerisation

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Identify the by-products of condensation polymerisation reactions	Name the small molecule produced in condensation polymerisation. Give the formula for the small molecule produced in condensation polymerisation.
TBAT Compare the processes of addition polymerisation and condensation polymerisation	Compare the products of addition and condensation polymerisation. Compare the structure of monomers used in addition and condensation polymerisation.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 15: Taking it Further: Naturally Occurring Polymers

Intended outcome	Example questions
**These are the main objectives for the lesson. For a detailed breakdown of the knowledge and skills addressed, please consult the unit overview document.*	
TBAT Identify different naturally occurring polymers and their monomers	Name three naturally occurring polymers. Explain why starch is a polymer. Name the monomer used to make starch. Explain why proteins are polymers. Name the monomers used to make protein. Explain why DNA is a polymer. Name the monomer units in DNA.
TBAT Describe the structure of DNA	Describe the structure of DNA. Describe the parts that make up a nucleotide. Name the base pairs. Describe the shape of the DNA molecule.
(HT) TBAT Describe how polypeptides are produced from amino acids	Name the type of reaction through which polypeptides are formed from amino acids. Name the other product of these reactions.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 16: Feedback Lesson

Intended outcome	Example questions
Teacher to look at mastery quiz/exit tickets and choose intended outcomes.	
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Mastery Quiz Re-teach Planning

To be completed once you have reviewed your pupils' response to the mastery quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout another unit? When will that be taught?

Other notes

Advanced Subject Knowledge

Where does this learning lead?

This unit is the foundation of all organic chemistry that students will go on to study, which makes up a large chunk of the A-Level and AS Level course. Students will learn more about the properties of alkanes, alkenes and alcohols, including looking at more complex branching and IUPAC naming conventions. They will also look at the idea of isomers, as well as other organic compounds, including aldehydes and ketones. They will also continue to make links in biochemistry, looking at the structures of amino acids, proteins and DNA in much greater detail.

Have a look at the questions below and think about what this means for this unit.

How does learning from this unit develop at KS5?
What content from this unit is fundamental to student understanding at KS5?
How could you check that students have grasped these fundamentals?

Vocabulary and literacy

Tier 3 vocabulary that will need to be explicitly taught in context:

Alcohol	An organic compound that contains a hydroxyl (OH) group. *Ethanol is the **alcohol** found in alcoholic drinks.*
Alkane	A hydrocarbon molecule with the general formula C_nH_{2n+2}. *Methane, ethane and propane are all **alkanes**.*
Alkene	A hydrocarbon molecule with the general formula C_nH_{2n}. ***Alkenes** contain a carbon-carbon double bond.*
Amino acid	A naturally occurring monomer that contains two different functional groups. ***Amino acids** can be joined together to make polypeptides and proteins.*
Carboxyl group	The functional group found in carboxylic acids (-COOH). *Ethanoic acid contains a **carboxyl group**.*
Carboxylic acid	An organic compound that contains a carboxyl (COOH) group. *Ethanoic acid is a **carboxylic acid** found in vinegar.*
Catalyst	A substance that speeds up a chemical reaction without being used up. *Ethanol can be made from ethene, but this requires a **catalyst**.*
Combustion	A reaction where a substance burns in oxygen. ***Combustion** of alkanes produces carbon dioxide and water.*
Covalent bonding	The type of bonding found between non-metals, where electrons are shared to provide full outer shells. ***Covalent bonding** is found in both covalent molecules and giant covalent structures.*
Cracking	The process by which longer hydrocarbon chains are broken down into shorter hydrocarbons. ***Cracking** produces an alkane and an alkene.*
Crude oil	A finite resource found in rocks made from the ancient biomass of plankton. ***Crude oil** is a non-renewable resource that is used to provide fuels and make plastics.*
DNA	A molecule containing the genetic information for functioning and development of living organisms and viruses. ***DNA** is made up of two strands of repeating nucleotide units.*
Ester	An organic compound made through the reaction between an alcohol and a carboxylic acid. ***Esters** are often used in scented products as they have pleasant, fruity smells.*
Fermentation	An anaerobic process where glucose is broken down to produce ethanol and carbon dioxide. ***Fermentation** is a method of producing ethanol.*
Fractional distillation	The process by which crude oil is separated into groups of similar compounds based on their boiling points. *During **fractional distillation**, crude oil is evaporated and fractions condense at different temperatures.*

Functional group	An atom or group of atoms that is responsible for the chemical properties of a compound. *Alcohols, alkenes and carboxylic acids all contain a **functional group**.*
Homologous series	A group of compounds that have similar chemical properties and the same general formula. *The alkanes are a **homologous series** that all have the general formula C_nH_{2n+2}.*
Hydration	A process which adds water. *Alcohols can be made from alkenes by **hydration**.*
Hydrocarbon	A molecule that contains carbon and hydrogen atoms only. *Alkenes and alkanes are **hydrocarbons**.*
Hydroxyl group	The functional group found in alcohols (-OH). *Ethanol contains a **hydroxyl group**.*
Intermolecular forces	Attractive forces that hold molecules of a substance together. *Covalent molecules have low melting and boiling points because little energy is required to overcome the **intermolecular forces**.*
Molecule	A small group of non-metal atoms chemically joined together *There are millions of **molecules** of water in a swimming pool.*
Monomer	A repeating subunit used to make a polymer. *Glucose is the **monomer** that makes up starch (a polymer).*
Physical property	A property of a substance that can be observed at any time *A **physical property** of iron is that it is hard.*
Polymer	A substance made up of repeating subunits (monomers). *Plastic is a **polymer**.*
Saturated	A compound that contains only carbon-carbon single bonds. *Alkanes are **saturated** as they contain only single bonds between carbon atoms.*
Thermosetting	Polymers that do not melt when they are heated. *A **thermosetting** plastic's shape cannot be changed.*
Thermosoftening	Polymers that melt when they are heated. *The shape of a **thermosetting** plastic can be changed when it is heated.*
Unsaturated	A compound that contains one or more carbon-carbon double (or triple) bonds. *Alkenes are **unsaturated** as they contain a double bond between carbon atoms.*
Viscosity	A measure of a substance's resistance to flow or how easy it is to pour. *Water has a low **viscosity**, so is not very viscous, but honey has a high viscosity and is very viscous.*

Appendices

Appendix 1: Mark scheme for pre-unit quiz

C5.1 Pre-Unit Quiz: Carbon Chemistry Mark Scheme

Qu	Answer	Marks	Supporting information for fix-it tasks
1	C	1	Answering A suggests that the student might associate the number of shells with the group number, instead of the period number. Answering B suggests that the student might associate the number of electrons with the group number. *To fix it, give students some electronic configuration diagrams and ask them to identify the element in the Periodic Table, and then to write down the period and group number of that element.*
2	B	1	Answering A shows students have confused compounds and mixtures, which is a common error. Answering C shows that students have confused compounds and molecules or assumed that they are synonymous. *To fix it, review the definitions of compound, mixture and molecule and give students examples and non-examples to refer to. For example, hydrogen gas is a molecule but not a compound and sodium chloride is a compound but not a molecule.*
3	C	1	Answering A shows that students are not clear on the meaning of a molecule, which is a key definition for this unit. Answering B shows that students have confused ionic bonding with molecules. *To fix it, give students examples and non-examples to refer to. For example, hydrogen gas is a molecule but not a compound and sodium chloride is a compound but not a molecule.*
4	A	1	Answering B shows students have confused covalent and ionic bonding. Answering C shows that students have a misconception that an element cannot contain bonds. *To fix it, review the definition of a covalent bond and show students how elements can be diatomic and contain bonds.*
5	B	1	Answering A shows students have confused covalent and ionic bonding. Answering C shows that students have a misconception

			that metallic bonding occurs between metals and non-metals. *To fix it, review each different type of bonding and give students examples and non-examples, then plenty of practice identifying the type of bonding from given formulae.*
6	A	1	Answering B or C means students are mixing up ionic, covalent and metallic bonding. *To fix it, provide a diagram or model for each type of bonding and explain to students why bonding occurs in each. Ask students to explain this in their own word, and encourage their use of the correct terminology.*
7	C	1	Answering A, B or D suggests that students cannot recall which atoms make up diamond. *To fix-it, show students a diagram of diamond and label the key features. Ask students to do the same with a blank diagram.*
8	A	1	Answering B suggests a gap in knowledge about how many electrons are in the 2nd electron shell. Answering C suggests a misconception that the 2nd electron shell can hold 8 electrons so does always hold 8 electrons. *To fix it, reteach the rules of writing out electronic configuration and then give many practice questions.*
9	B	1	Answering A suggests some understanding that a full outer shell/stable configuration causes noble gases to be unreactive, but shows a gap in knowledge that helium has only two electrons in its outer shell. *To fix it, ask students to draw out the electronic configuration of helium, neon and argon.* Answering C suggests that students have the misconception that a stable electron arrangement is an atom being electrically neutral. *To fix it, show diagrams of different types of atom, where they have equal numbers of protons and electrons, but do not have a full outer shell.*
10	B	1	Answering A or C suggests that students are confusing the term polymer with plastic or an example of a plastic (such as a thermosoftening plastic). *To fix it, support pupils to define the term polymer with some examples, and then differentiate this with some specific examples of plastic, such as thermosoftening and thermosetting plastics.*

Appendix 2: Mark Scheme for Mastery Quiz

P5.1 Mastery Quiz: Electromagnetic Radiation Mark Scheme

Section A

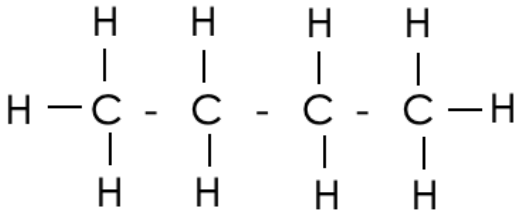
Qu	Answer	Marks	Supporting information for fix-it tasks
1	A	1	Answering B or C suggests that students are unable to identify where crude oil comes from. *To fix it, review where crude oil is found and where it has come from.*
2	B	1	Answering A suggests that students have confused crude oil with a single hydrocarbon, which is a common error. Answering C suggests that students are not clear on the definition of a molecule. *To fix it, review the definitions of compound, mixture and molecule and give students example formulae and mixtures to classify.*
3	B	1	Answering A or C means students are mixing up the naming of alkanes. *To fix it, review the general formula for alkanes and the acronym for naming the first four: monkeys eat peanut butter.*
4	B	1	Answering A shows students have doubled the number of carbons but forgotten the +2. Answering C shows that students have added two before doubling, so have used the incorrect order of operations. *To fix it, give students lots of practice working out the number of carbons and hydrogens in different alkanes.*
5	A	1	Answering B or C suggests that students cannot recall that covalent bonding is between non-metals atoms. This is a common error where students struggle to relate large molecules to simple molecules. *To fix it, review the definition of a covalent bond and the full dot and cross diagrams for the first four alkanes.*
6	C	1	Answering A shows that students have added the given numbers together. Answering B shows that students have seen the formula of the product is C_nH_{2n} and assumed that both products would have the same general formula.

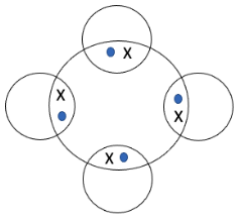
			To fix it, give students practice determining products from cracking equations.
7	A	1	Answering B suggests that students have confused cracking and fractional distillation. Answering C shows that students are not clear that shorter hydrocarbon chains are more useful/more in demand. *To fix it, review the uses of short chain and long chain hydrocarbons and get students to explain why there may be higher demand for petrol hydrocarbons rather than kerosene hydrocarbons.*
8	D	1	Answering A or B show that students have confused the test for saturation with the test for carbon dioxide, which is a common error. Answering B shows that students recognise the colour change is to colourless. Answering C shows that students have recognised that bromine water is used for the test but have confused a positive result with that of a positive test for carbon dioxide. *To fix it, review the test for saturation and give students examples of compounds (ethane, ethene, propane, propene etc) to determine if they would test positive or negative for saturation.*
9	C	1	Answering A suggests that the students have just read the stages in order. Answering B shows that students have not understood that the reason that hydrocarbons evaporate is because the crude oil is heated. *To fix it, review the process of fractional distillation and get students to summarise the steps in their own words.*
10	A	1	Answering B suggests that students have confused melting and boiling points. Answering C suggests the common misconception that the different hydrocarbons themselves have different temperatures rather than boiling points. *To fix it, show students a simple model using distillation to show that the whole mixture is heated and the compounds within in boil at different temperatures.*
11	B	1	Answering A or C suggests that students are mixing up the products with oxygen as a reactant. *To fix it, review the definition of a combustion reaction and get*

			students to write the general equation for the combustion of alkanes.
12	B	1	Answering A shows that students know there is a limiting reactant involved but not identified this as oxygen. Answering C shows that students have not understood that oxygen is in excess for complete combustion reactions. *To fix it, review the difference between complete and incomplete combustion.*
13	A	1	Answering B shows that students have recognised combustion as exothermic but not selected the correct definition of an exothermic reaction. Answering C or D suggests that students have not recognised combustion as exothermic, although answering C shows that they have recognised energy is transferred to the surroundings. *To fix it, remind students of the definitions of exothermic and endothermic reactions and show students a reaction profile for alkane combustion, asking them to explain what it shows.*
14	B	1	Answering A suggests that students are mixing up alkanes and alkenes and unclear on the naming conventions for polymers. Answering C shows that students have confused the monomer with the homologous group. *To fix it, ask students to determine the name of the polymer that would be formed from different monomers.*
15	B	1	Answering A shows that students are not clear on what incomplete combustion means. Answering C shows that students are aware that sulfur is related to general pollution but have not made the link between sulfur and sulfur dioxide. *To fix it, review the disadvantages of burning hydrocarbons and explain how this is linked to acid rain.*
16 (SS)	C	1	Answering A or B shows that students are not secure on the naming of different homologous groups. *To fix it, give students lots of practice naming compounds from given written and full structural formulae.*
17 (SS)	C	1	Answering A or B shows that students are not clear on the meaning of a functional group.

			To fix it, review the functional groups of each of the homologous series and get students to highlight/circle them on diagrams.
18 (SS)	B	1	Answering A shows that students are not clear on the difference between carboxylic acids and esters. Answering C shows that students have confused polymerisation reactions with the formation of esters. *To fix it, show students how esters are still small molecules so are not polymers but can be added together to create poly(esters) through condensation polymerisation.*
19 (SS)	A	1	Answering B shows that students are not secure with deriving the monomer formula from a polymer. Answering C shows that students have identified the atoms but not the importance of the double bond in the monomer. *To fix it, review why alkenes can form polymers but alkanes cannot.*
20 (SS)	A	1	Answering B shows that students have confused addition and condensation polymerisation. Answering C shows that students have confused the process of making an ester with condensation polymerisation. *To fix it, review the processes of addition and condensation polymerisation using diagrams.*

Section B

Qu	Model answer	Indicative marks	Supporting information ***Suggestions for fix-it tasks***
1a		2 Allow 1 for correct number of hydrogen atoms	
1b	C_4H_{10}	1	
2a	Methane: Gas Hexane: Liquid	2	
2b	• Both are hydrocarbons/contain hydrogen and carbon atoms • Methane has 1 carbon atom, hexane has 6 • Methane has 4 hydrogen atoms, hexane has 14	4	*To fix-it, go through each of the suggested*

	• Both contain covalent bonds • Methane only contains C-H bonds, hexane also contains C-C bonds • Both are small molecules • Hexane is a larger molecule than methane • Methane is a gas at room temperature whereas hexane is a liquid • Hexane has a higher melting point than methane • Hexane has a higher boiling point than methane • There are weak forces between molecules in both methane and hexane • The intermolecular forces between molecules of hexane are stronger than in methane • Hexane is more viscous than methane • Methane is more flammable than hexane • Both produce carbon dioxide and water through combustion		*points and get students to identify whether they are comparing structure or properties, then repeat the question for two different alkanes.*
2c	Boiling point increases as the number of (carbon) atoms increases <u>Because</u> the intermolecular forces increase	2	
2d		2	
3a	COOH	1	*Many students write carboxyl group rather than the formula, which is a common error in exam questions*
3b	In alcoholic drinks or as a solvent	1	
3c	Ester + water	2	
3d	Level 0 (0 marks): no relevant content Level 1 (1-2 marks): relevant points may be made but are not connected Level 2 (3-4 marks): relevant points are made and there is an attempt at linking **or** a conclusion Level 3 (5-6 marks): relevant points are logically linked with a justified conclusion Suggested points: *Advantages of fermentation*		

	• Low energy usage • Raw material used is renewable *Disadvantages of fermentation* • Produces low purity ethanol • Relatively low rate of reaction *Advantages of hydration* • High energy usage, therefore expensive • Raw material used is non-renewable *Disadvantages of hydration* • Produces high purity ethanol • Relatively high rate of reaction		

Appendix 3: Core Knowledge Statements

Crude Oil and Hydrocarbons

1. Crude oil is a finite resource found in rocks.
2. Crude oil is the remains of an ancient biomass consisting mainly of plankton that was buried in mud.
3. Crude oil is a mixture of a very large number of compounds. Most of the compounds in crude oil are hydrocarbons.
4. Hydrocarbons are molecules made up of hydrogen and carbon atoms only.
5. Most of the hydrocarbons in crude oil are hydrocarbons called alkanes.
6. The general formula for the homologous series of alkanes is C_nH2_{n+2}
7. The first four members of the alkanes are methane, ethane, propane and butane.
8. Many useful materials on which modern life depends are produced by the petrochemical industry, such as solvents, lubricants, polymers, detergents.
9. The vast array of natural and synthetic carbon compounds occur due to the ability of carbon atoms to form families of similar compounds.

Fractional Distillation

10. The many hydrocarbons in crude oil may be separated into fractions, each of which contains molecules with a similar number of carbon atoms, by fractional distillation.
11. The fractions can be processed to produce fuels and feedstock for the petrochemical industry.
12. Many of the fuels on which we depend for our modern lifestyle, such as petrol, diesel oil, kerosene, heavy fuel oil and liquefied petroleum gases, are produced from crude oil.
13. During fractional distillation, a fractionating column is used. This column has condensers at varying heights.
14. A fractionating column is hot at the bottom and cooler at the top
15. Substances with high boiling points condense at the bottom and those with low boiling points condense at the top
16. During fractional distillation, crude oil is evaporated. It's vapours condense at different temperatures in the fractionating column.
17. Each fraction produced during fractional distillation has a similar number of carbons (or size of hydrocarbons)
18. Some properties of hydrocarbons depend on the size of their molecules, including boiling point, viscosity and flammability. These properties influence how hydrocarbons are used as fuels.
19. Boiling point, viscosity and flammability change with increasing molecular size.

Combustion of Hydrocarbons

20. The combustion of hydrocarbon fuels releases energy.
21. During combustion, the carbon and hydrogen in the fuels are oxidised.
22. The complete combustion of a hydrocarbon produces carbon dioxide and water.
23. The general word equation that describes the complete combustion of an alkane is:

alkane + oxygen → carbon dioxide + water

24. Complete combustion reactions of alkanes can be represented by balanced symbol equations, for example:

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

25. Incomplete combustion can occur if there is not enough oxygen. In this case, carbon, carbon monoxide are produced.

Cracking

26. Hydrocarbons can be broken down (cracked) to produce smaller, more useful molecules.
27. Cracking can be done by various methods including catalytic cracking and steam cracking.
28. The products of cracking include alkanes and another type of hydrocarbon called alkenes.
29. Alkenes are more reactive than alkanes and react with bromine water, which is used as a test for alkenes.
30. If alkenes are present, the bromine water will turn from orange to colourless.
31. Alkenes are used to produce polymers and as starting materials for the production of many other chemicals.
32. There is a high demand for fuels with small molecules and so some of the products of cracking are useful as fuels.

Polymers

33. Polymers have very large molecules. The atoms in the polymer molecules are linked to other atoms by strong covalent bonds.
34. Polymers can be represented in brackets, where n is a large number
35. The intermolecular forces between polymer molecules are relatively strong and so these substances are solids at room temperature.
36. The properties of polymers depend on what monomers they are made from and the conditions under which they are made. For example, low density (LD) and high density (HD) poly(ethene) are produced from ethene.
37. Thermosoftening polymers melt when they are heated.
38. Thermosetting polymers do not melt when they are heated.

Alkenes (Chemistry only)

39. Alkenes are hydrocarbons with a double carbon-carbon bond.
40. The general formula for the homologous series of alkenes is C_nH_{2n}
41. Alkene molecules are unsaturated because they contain two fewer hydrogen atoms than the alkane with the same number of carbon atoms.
42. The first four members of the homologous series of alkenes are ethene, propene, butene and pentene.
43. Alkenes can be represented with a chemical formula or a displayed formula
44. Alkenes react with oxygen in combustion reactions in the same way as other hydrocarbons, but they tend to burn in air with smoky flames because of incomplete combustion.
45. Alkenes react with hydrogen, water and the halogens, by the addition of atoms across the carbon-carbon double bond so that the double bond becomes a single carbon-carbon bond.
46. Alkenes are hydrocarbons with the functional group C=C.

Alcohols (Chemistry only)

47. It is the generality of reactions of functional groups that determine the reactions of organic compounds.

48. Alcohols contain the functional group –OH (a hydroxyl group)
49. Methanol, ethanol, propanol and butanol are the first four members of a homologous series of alcohols.
50. Methanol is used as a chemical feedstock.
51. Ethanol is the alcohol present in alcoholic drinks
52. Ethanol is used as a solvent.
53. Propanol is used as a fuel and a solvent.
54. If a small piece of sodium is dropped into ethanol, bubbles of hydrogen gas are produced and the liquid contains sodium ethoxide
55. The reaction between sodium and ethanol can be represented by the equation:

sodium + ethanol → sodium ethoxide + hydrogen gas

56. This reaction can be represented by the balanced symbol equation:

$2\ Na + 2\ C_2H_5OH \rightarrow 2\ C_2H_5ONa + H_2$

57. Ethanol can be produced by fermentation or from ethene
58. Ethanol is concentrated by distillation.
59. Fermentation is an anaerobic process.
60. The equation for the production of ethanol by fermentation is:
glucose → ethanol + carbon dioxide
61. Yeast provides the enzymes that are needed for fermentation
62. The typical conditions required for fermentation are

- anaerobic conditions (no oxygen present)
- sugar dissolved in water, with yeast mixed in
- a warm temperature (25-35 degrees Celsius)

63. Fermentation is a slow reaction which may take days or weeks to finish.
64. Alcohols with short hydrocarbon chains mix with water easily to form a solution
65. The solubility of alcohols decreases as the size of the hydrocarbon chain increases
66. Alkenes can be hydrated to produce alcohols according to the equation:

Alkene + water (steam) → alcohol

67. This is called hydration, and it needs a temperature of approximately 300°C and a catalyst.
68. For example:

Butene + water → butanol

69. Ethanol can be manufactured by the hydration of ethene
70. The ethene for this reaction comes from cracking crude oil fractions
71. In this process, ethene is heated with steam in the presence of a catalyst of phosphoric acid
72. The catalyst speeds up the reaction
73. The word equation for this reaction is:

ethene + steam → ethanol

74. The chemical equation for this reaction is:

$C_2H_4 + H_2O \rightarrow C_2H_5OH$

75. The conditions for this reaction are

- a high temperature (around 300 °C)
- a pressure of 60-70 atmospheres

76. Ethanol is the only product of this reaction
77. This is a continuous reaction, which means that as long as ethene and steam are fed into the reaction, ethanol will be produced continually. This makes it an efficient process.
78. Ethene is made from crude oil which is a non-renewable resource.
79. The reaction of ethene with steam can be reversed, allowing ethanol to be converted back to ethene.

80. A catalyst called aluminium oxide can speed up this reaction
81. The word equation for this reaction is:
ethanol → ethene + steam
82. The chemical equation for this reaction is:
$C_2H_5OH \rightarrow C_2H_4 + H_2O$

Carboxylic Acids and Esters (Chemistry only)

83. Carboxylic acids have the functional group –COOH.
84. The functional group -COOH is also called the carboxyl group
85. Carboxylic acids can be represented using a chemical formula or a displayed formula
86. Carboxylic acids have the same general formula: $C_nH_{2n+1}COOH$, where n is the number of carbon atoms in the molecule minus 1 (or $C_nH_{2n}O_2$)
87. The first four members of a homologous series of carboxylic acids are methanoic acid, ethanoic acid, propanoic acid and butanoic acid.
88. Carboxylic acids are weak acids, which have the typical properties of acids.
89. Carboxylic acids dissolve in water to form acidic solutions with pH values of less than 7
90. Vinegar is a dilute solution of ethanoic acid
91. Carboxylic acids react with carbonates to form a salt, water and carbon dioxide
92. Because carboxylic acids are weak acids, their solutions do not contain many hydrogen ions compared to a strong acid of the same concentration
93. Carboxylic acids can react with alcohols to make esters
94. Esters contain the functional group -COO-
95. Esters have fruity smells and can be used as solvents
96. The general equation for the formation of an ester is:

alcohol + carboxylic acid → ester + water

97. For example:

ethanol + ethanoic acid → ethyl ethanoate + water

Polymerisation (Chemistry only)

98. Alkenes can be used to make polymers such as poly(ethene) and poly(propene) by addition polymerisation.
99. In addition polymerisation reactions, many small molecules (monomers) join together to form very large molecules (polymers).
100. In addition polymers the repeating unit has the same atoms as the monomer because no other molecule is formed in the reaction.
101. Condensation polymerisation involves monomers with two functional groups.
102. When these types of monomers react they join together, usually losing small molecules such as water, and so the reactions are called condensation reactions.
103. The simplest polymers are produced from two different monomers with two of the same functional groups on each monomer.
104. Amino acids have two different functional groups in a molecule.
105. Amino acids react by condensation polymerisation to produce polypeptides.
106. Different amino acids can be combined in the same chain to produce proteins.
107. DNA (deoxyribonucleic acid) is a large molecule essential for life.

108. DNA encodes genetic instructions for the development and functioning of living organisms and viruses.
109. Most DNA molecules are two polymer chains, made from four different monomers called nucleotides, in the form of a double helix.
110. Other naturally occurring polymers important for life include proteins, starch and cellulose.

Disciplinary Knowledge

97. Use SI units (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.

Practical Skills

41. Safe use of equipment to separate mixtures using distillation