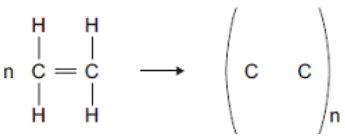
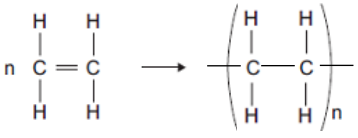
C7: Organic Chemistry 1

ANSWER KEY

17.1	What is crude oil?	A mixture of hydrocarbons
17.2	**What is crude oil formed from?**	**The remains of ancient biomass (mostly plankton)**
17.3	Crude oil is a finite resource. What is meant by a finite resource?	One that will run out (non-renewable)
17.4	**What is a hydrocarbon?**	**A compound made of atoms of carbon and hydrogen only**
17.5	What is an alkane?	A hydrocarbon with only single bonds
17.6	How many covalent bonds does each carbon atom form in an alkane?	4
17.7	**Name the first four alkanes**	• **Methane (Monkeys)** • **Ethane (Eat)** • **Propane (Peeled)** • **Butane (Bananas)**
17.8	**What is the general formula for alkanes?**	**C_nH_{2n+2}**
17.9	How does boiling point change as alkane molecules get longer?	The longer the molecule, the higher its boiling point
17.10	**Why does the boiling point increase?**	• **stronger forces of attraction** • **between the longer molecules** • **so more heat energy needed to separate the molecules**
17.11	How does viscosity change as alkane molecules get longer?	The longer the alkane, the more viscous (the thicker) it is
17.12	How does flammability change as alkane molecules get longer?	The longer the alkane, the less flammable it is
17.13	What is fractional distillation?	A process used to separate mixtures of substances with different boiling points
17.14	**What are the steps involved in fractional distillation?**	• **Crude oil is heated into vapour** • **which rises up tower, cools, condenses** • **similar chain lengths condense at similar points on tower** • **as they have similar boiling points** • **Smallest molecules stay as gas and collect at top of tower**

C7: Organic Chemistry 2

ANSWER KEY

18.1	Why is fractional distillation important?	Because the different fractions have different uses
18.2	What is fuel?	A substance which releases energy when reacted with oxygen
18.3	What is combustion?	The reaction of a fuel with oxygen
18.4	**What are the products of complete combustion of hydrocarbon fuels?**	**Carbon dioxide and water**
18.5	**When does incomplete combustion occur?**	**When there is not enough oxygen present**
18.6	**What are the products of incomplete combustion of hydrocarbon fuels?**	**Carbon monoxide, carbon and water**
18.7	**What is cracking?**	**The process of breaking down a long hydrocarbon into smaller hydrocarbons**
18.8	What are the products of cracking?	Short alkanes and alkenes
18.9	Why is cracking important?	Because smaller hydrocarbons are more useful than longer ones
18.10	**Why are shorter chain alkanes in higher demand than longer chains?**	**They are more flammable, and make better fuels**
18.11	What are the two types of cracking?	Catalytic and steam cracking
18.12	**What are the conditions used for cracking?**	**High temperature and a catalyst**
18.13	What are alkenes?	A different type of (more reactive) hydrocarbon with a double bond
18.14	What are alkenes uses for?	As a starting material to make more useful chemicals like polymers (plastics)
18.15	Complete the diagram below showing the formation of poly(ethene) 	 • single bonds between all C/H atoms • trailing bonds through brackets
18.16	**What is the correct test and observation for an alkene?**	• **add <u>bromine</u> water** • **orange → colourless**

C7: Further Organic - Alkenes (Triple Content)

ANSWER KEY

1	What is an alkene?	A hydrocarbon with a double bond
2	**What is the general formula for alkenes?**	**C_nH_{2n}**
3	What does unsaturated mean?	Contains double bonds (which could become C-H bonds)
4	What are the first four alkenes?	Ethene, propene, butene, pentene
5	What functional group do all alkenes have?	C=C
6	How is the combustion of alkenes different to combustion of alkanes?	Alkenes usually react by incomplete combustion so burn with smoky flames
7	Why are the reactions of alkenes with hydrogen, water and halogens known as “addition” reactions?	Because new atoms are being added to the molecule by breaking the double bond
8	What is the product from the reaction of an alkene with hydrogen?	An alkane
9	What conditions are necessary in the reaction of alkenes with hydrogen?	Warm (60°C), Nickel catalyst
10	What is the product from the reaction of alkene with a halogen e.g. Cl_2?	An alkane with two halogen (chlorine) atoms on the carbon atoms where the double bond used to be
11	What is the product from the reaction of an alkene with steam?	An alcohol
12	What conditions are necessary for the reaction of alkenes with steam?	High temperature, high pressure, catalyst

C7: Further Organic - Alcohols and Carboxylic Acids (Triple Content)

ANSWER KEY

1	**What functional group do all alcohols have?**	**-OH**
2	Name the first four alcohols	Methanol, ethanol, propanol, butanol
3	What is formed when an alcohol reacts with sodium?	A sodium salt (e.g. sodium ethoxide from ethanol) and hydrogen gas
4	What is produced when an alcohol burns in oxygen?	Carbon dioxide and water
5	Do alcohols dissolve in water?	Yes - they form neutral solutions
6	**What is formed when alcohols are oxidised?**	**Carboxylic acids**
7	What are the main uses of alcohols?	Solvents, fuels, ethanol is used as drinking alcohol
8	What is fermentation?	The process of turning glucose (a natural sugar) into ethanol
9	**What are the essential conditions for fermentation?**	• **Glucose** • **Yeast** • **Aqueous conditions** • **Warm (40°C)** • **Anaerobic conditions**
10	**What functional groups do all carboxylic acids have?**	**-COOH**
11	Name the first four carboxylic acids	Methanoic acid, ethanoic acid, propanoic acid, butanoic acid
12	**Are carboxylic acids weak or strong acids?**	**Weak acids**
13	What is formed when ethanoic acid reacts with sodium carbonate?	Sodium ethanoate, water and carbon dioxide
14	What is formed when an alcohol reacts with a carboxylic acid?	An ester
15	**What is formed when ethanol reacts with ethanoic acid?**	**Ethyl ethanoate and water**

C7: Further Organic - Polymers (Triple Content)

ANSWER KEY

1	**What is polymerisation?**	**The process of joining many small molecules (monomers) to make a long chain molecule (polymer)**
2	**What are the two types of polymerisation?**	**Addition and condensation**
3	What monomers are involved in addition polymerisation?	Alkenes
4	**How many products are formed in addition polymerisation?**	**One - the polymer only**
5	What type of monomers are involved in condensation polymerisation?	Ones with two different functional groups e.g. an alcohol and a carboxylic acid
6	**How many products are formed in condensation polymerisation?**	**Two - the polymer and a small molecule (usually water)**
7	Which functional groups do amino acids have?	$-NH_2$ and -COOH
8	What do amino acids form during a condensation reaction?	Polypeptides and proteins
9	What does DNA stand for?	Deoxyribonucleic acid
10	**What is the structure of DNA?**	• **2 polymer chains** • **twisted in a double helix** • **held together by 4 different nucleotides**
11	Name four naturally occurring polymers	DNA, protein, starch, cellulose
12	**What monomers are starch and cellulose made of?**	**Glucose**
13	**What monomers are proteins made of?**	**Amino acids**

FOUNDATION TIER

Q1. Alkanes are hydrocarbons found in crude oil.

(a) (i) Complete the sentence. Hydrocarbons contain the elements _____ and _____ only.

(1)

(ii) Ethane is an alkane with the formula C_2H_6

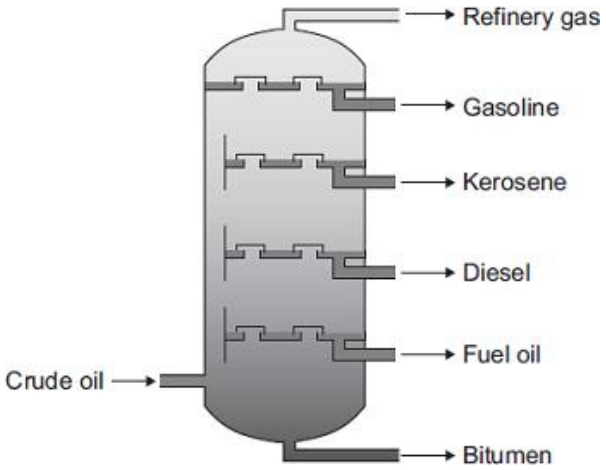
Draw a ring around the correct answer to complete the sentence.

Alkanes are hydrocarbons with the general formula

C_nH_n
C_nH_{2n}
C_nH_{2n+2}

(1)

(b) Crude oil is separated into useful fractions by fractional distillation.



Describe and explain how crude oil is separated into fractions by fractional distillation.

Use the diagram to help you answer the question.

_____

_____

_____

_____

_____

_____

_____

(4)

(c) Dodecane ($C_{12}H_{26}$) from crude oil is cracked to produce ethene (C_2H_4).

(i) Complete the equation for this reaction.

$C_{12}H_{26} \longrightarrow 2\ C_2H_4 +$ _____

(1)

(ii) Give **two** conditions needed for cracking.

1. _____

2. _____

(2)

(Total 9 marks)

Q2. Crude oil is a resource found in rocks. Most of the compounds in crude oil are hydrocarbons.

(a) Complete the sentence.

Crude oil is formed by the decomposition of _____.

(1)

(b) Alkanes are hydrocarbons.

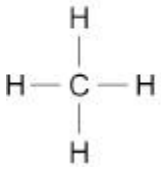
Give the name of the alkane molecule that has three carbon atoms.

_____

(1)

(c) The figure below shows two alkane molecules.

Methane



Hexane

The table below shows the melting points and boiling points of methane and hexane.

	Melting point in °C	**Boiling point in °C**
Methane	−183	−162
Hexane	−95	69

Compare the structure and properties of methane and hexane.

_____

(6)

Hydrocarbons are cracked to produce more useful alkanes and alkenes.

(d) Decane ($C_{10}H_{22}$) is cracked to produce **two** products.

Complete the equation for the reaction.

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

(1)

(e) C_2H_4 is an alkene.

What is the test for alkenes?

Give the result of the test if an alkene is present.

Test _____

Result _____

(2)

(Total 11 marks)

HIGHER TIER

Q3. This question is about crude oil and alkanes.

(a) Describe how crude oil is formed.

(3)

The table below shows the boiling points of three alkanes.

Alkanes	Boiling point in °C
C_5H_{12}	36
$C_{10}H_{22}$	174
$C_{15}H_{32}$	271

(b) What is the general formula for alkanes?

(1)

(c) Explain the trend in the boiling points of the alkanes.

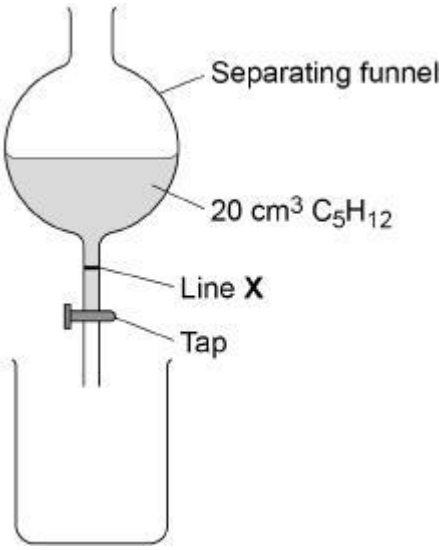
(3)

(d) A student investigated one property of the alkanes C_5H_{12}, $C_{10}H_{22}$ and $C_{15}H_{32}$

This is the method used.

1. Pour 20 cm^3 of C_5H_{12} into a separating funnel.
2. Open the tap of the separating funnel and start a timer.
3. Stop the timer when the level of C_5H_{12} reaches line **X**.
4. Repeat steps 1 to 3 with $C_{10}H_{22}$ and $C_{15}H_{32}$

The diagram below shows the apparatus used.



The level of C_5H_{12} takes 6.4 seconds to reach line **X**.

Predict the trend in times for the other two alkanes.

Give **one** reason for your answer.

Trend _____

_____

Reason _____

_____

(2)

(Total 9 marks)

Q4. This question is about crude oil.

(a) The table shows information about crude oil fractions.

Crude oil fraction	Number of carbon atoms	Approximate percentage (%) in crude oil	Approximate percentage (%) demand
Gas	1–4	3	4
Petrol	5–10	9	23
Naphtha	8–12	10	5
Kerosene	9–16	14	8
Diesel	15–25	16	22
Residue	20–30+	48	38

Explain the advantage of cracking hydrocarbons.

Give **one** example from the table.

(3)

(b) Ethene is a product of cracking.

Relative formula mass (M_r) of ethene = 28

Calculate the number of moles of ethene (C_2H_4) in 50.4 kg

Give your answer in standard form.

Numbers of moles = _____

(3)

(c) $C_{21}H_{44}$ can be cracked to produce ethene.

$$C_{21}H_{44} \rightarrow 3C_2H_4 + C_{15}H_{32}$$

Relative formula mass (M_r) of $C_{21}H_{44}$ = 296

Calculate the mass of $C_{21}H_{44}$ needed to produce 50.4 kg of ethene.

_____

_____

_____

_____

_____

Mass = _____ kg

(3)

(Total 9 marks)

SEPARATE SCIENCE

Q5. This question is about cycloalkenes.

Cycloalkenes are ring-shaped hydrocarbon molecules containing a double carbon-carbon bond.

Cycloalkenes react in a similar way to alkenes.

(a) Describe a test for the double carbon-carbon bond in cycloalkene molecules.

Give the result of the test.

Test _____

Result _____

(2)

(b) The table below shows the name and formula of three cycloalkenes.

Name	**Formula**
Cyclobutene	C_4H_6
Cyclopentene	C_5H_8
Cyclohexene	C_6H_{10}

Determine the general formula for cycloalkenes.

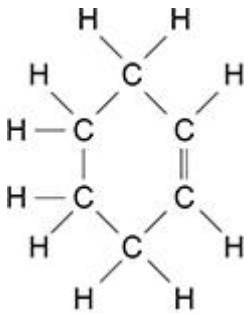
_____

General formula = _____

(1)

Figure 1 shows the displayed structural formula of cyclohexene, C_6H_{10}

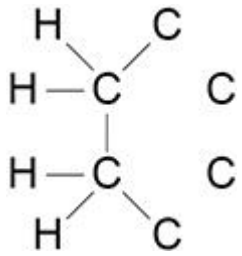
Figure 1



Chlorine reacts with cyclohexene to produce a compound with the formula $C_6H_{10}Cl_2$

(c) Complete **Figure 2** to show the displayed structural formula of $C_6H_{10}Cl_2$

Figure 2



(2)

(d) Calculate the percentage by mass of chlorine in a molecule of $C_6H_{10}Cl_2$

Relative atomic masses (A_r): H = 1 C = 12 Cl = 35.5

_____

_____

_____

_____

Percentage by mass = _____ %

(3)

(Total 8 marks)

Q6. This question is about carboxylic acids.

Carboxylic acids belong to a homologous series.

The table below shows information about the first three carboxylic acids in this homologous series.

Name	**Formula**	**pH of a 0.01 mol/dm^3 solution**
Methanoic acid		2.91
Ethanoic acid	CH_3COOH	3.39
	CH_3CH_2COOH	3.44

(a) Complete the table above.

(2)

(b) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

Explain how the equation shows that ethanoic acid is a weak acid.

(2)

(c) A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

(3)

(d) The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm^3 methanoic acid
- 0.01 mol/dm^3 ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.

Explain why.

You should refer to ions in your answer.

Use the table above.

(3)

Ethanoic acid reacts with ethanol to produce an ester.

(e) Give the name of the ester produced when ethanoic acid reacts with ethanol.

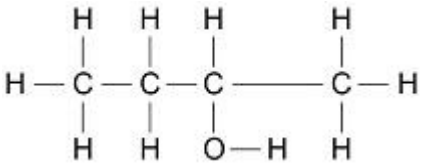
(1)

(f) Hexanedioic acid and ethanediol join together to produce a polyester.

Ethanoic acid and ethanol join together in the same way to produce an ester.

Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?

Tick (✓) **one** box.



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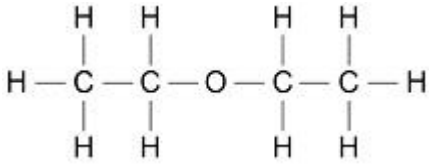

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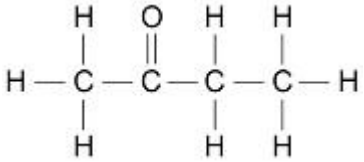

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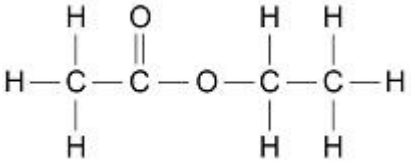


☐

(1)

(Total 12 marks)

Q7. This question is about algae.

A student:

- placed algae in water containing dissolved carbon dioxide
- shone bright light on the algae.

Gas bubbles were collected as the algae photosynthesised.

(a) Describe a test that would identify the gas collected.

Give the result of the test.

Test _____

Result _____

_____

(2)

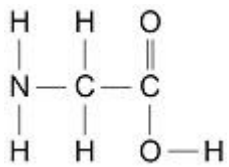
(b) Glucose is produced when algae photosynthesise.

Name **two** naturally occurring polymers produced from glucose.

_____ and _____

(2)

The diagram below shows the displayed structural formula of an amino acid called glycine.



(c) How many functional groups are there in the molecule in the diagram above?

1 ☐ 2 ☐ 3 ☐ 4 ☐

(1)

(d) Glycine reacts by condensation polymerisation to produce a polypeptide and one other substance.

Name the other substance produced.

_____

(1)

(e) Scientists think that algae may have used gases in Earth's early atmosphere.

Algae need an element to produce the molecule in the diagram above which is **not** present in water or carbon dioxide.

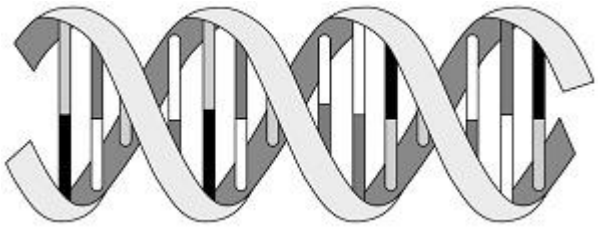
Which **two** gases from Earth's early atmosphere could have provided this element?

_____ and _____

(2)

(f) The development and function of algae are controlled by a naturally occurring polymer.

The image below represents the shape and structure of this polymer.



Describe the shape and structure of this polymer.

_____

_____

_____

_____

_____

_____

(3)

(Total 11 marks)

Mark schemes

Q1.

(a) (i) hydrogen / H and carbon / C

answers can be in either order

if letters given, must be capital H

1

(ii) C_nH_{2n+2}

1

(b) (most) crude oil <u>vaporises / evaporates</u> **or** crude oil enters as a <u>vapour</u>

1

(vapour) cools as it rises up the tower / column **or** tower / column cooler at the top **or** negative temperature gradient

1

the fractions have different boiling / condensation points / ranges

accept the larger the molecules, the higher the boiling point / condensation point

1

so they will condense at different levels in the tower

allow will collect at different levels if condensation mentioned

allow will condense to give different fractions

*if no other mark is gained allow **1** mark for mention of heating*

1

(c) (i) C_8H_{18}

if one answer is given C_8H_{18} is the only acceptable answer

credit any correct combination of alkanes and alkenes, eg C_5H_{12} and C_3H_6

1

(ii) hot / high temperature

accept any temperature in the range 300 − 900 °C
'heat' is insufficient

1

catalyst

*accept a named catalyst − alumina **or** zeolites **or** aluminosilicates **or** broken pot*

ignore other named catalysts

allow (mixing with) steam as an alternative to second marking point ignore pressure

1

[9]

Q2.

(a) plankton

or

(ancient) biomass

allow microscopic plants / animals

1

(b) propane

allow C_3H_8

1

(c) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.

4–6

Level 1: Relevant features are identified and differences noted. 1–3 AO1 AO2

1–3

No relevant content

0

Indicative content

- methane has 1 carbon atom, hexane has 6
- methane has 4 hydrogen atoms, hexane has 14
- both contain C – H bonds
- only hexane contains C – C bonds
- both are hydrocarbons

- hexane has a higher melting point than methane (or converse)
- hexane has a higher boiling point than methane (or converse)
- methane is a gas at room temperature
- hexane is a liquid at room temperature

- both are small molecules
- hexane has larger molecules than methane
- weak forces between molecules
- forces between hexane molecules stronger than between methane molecules

- hexane is more viscous than methane
- both are flammable
- methane is more flammable than hexane (or converse)
- possible products of combustion from both are: carbon, carbon monoxide, carbon dioxide, water
- neither conduct electricity

(d) C_8H_{18}

1

(e) bromine (water)

1

turns (from orange / brown) to colourless

MP2 is dependent on MP1 allow decolourises
ignore clear

1

[11]

Q3.

(a) plankton

allow biomass
allow (marine) animals / organisms
ignore plants

1

buried in mud

allow compressed under mud
allow compressed in sedimentary rock
ignore fossilised

1

over a long period of time
or
over millions of years

1

(b) C_nH_{2n+2}

1

(c) *max **2** marks for incorrect reference to particles / bonds*

allow converse

the boiling point increases as the number of (carbon) atoms increases

1

(because the weak) intermolecular forces increase
or
(because the weak) forces between the molecules increase

1

(and these intermolecular forces increase) as the size of the molecules increases

1

(d) *MP2 dependent on correct response in MP1*

(as number of carbon atoms increase) the time increases

1

(because) the viscosity increases

1

[9]

Q4.

(a) break large molecules into small molecules

1

to satisfy demand

1

example

1

(b) 50.4 kg = 50 400 g

1

50 400/28

1

1.8×10^3

1

(c) 1.8/3 = 0.6

1

0.6 × 296

1

= 177.6 kg

1

[9]

Q5.

(a) (test)
(add) bromine (water)

1

(result)
(changes from) brown / orange to colourless

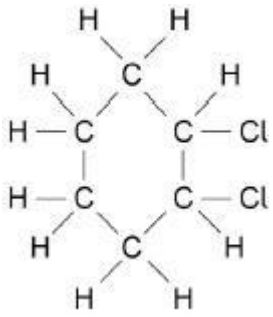
ignore clear

1

(b) C_nH_{2n-2}

1

(c)



*allow **1** mark for the structure of*
*1, 1-dichlorocyclohexane **or***
*1, 3-dichlorocyclohexane **or***
1, 4-dichlorocyclohexane

2

(d) (M_r ($C_6H_{10}Cl_2$) =) 153

1

(% chlorine=) $\frac{71}{153} \times 100$

allow correct use of an incorrectly calculated value of M_r

1

= 46.4 (%)

allow 46.405228758 (%) correctly rounded to at least 2 significant figures

1

[8]

Q6.

(a) HCOOH

allow HCO_2H

1

propanoic acid

1

(b) incomplete / partial ionisation

allow incomplete / partial dissociation

1

(because) reaction is reversible

allow (because) reaction is in equilibrium

1

(c) mass (of flask and contents) decreases

1

(because) carbon dioxide is produced

1

(and) carbon dioxide escapes (from the flask)

*allow **1** mark for the gas produced escapes (from the flask)*

1

(d) (0.01 mol/dm^3) methanoic acid has a lower pH

allow converse argument for ethanoic acid

allow (0.01 mol/dm^3) methanoic acid is a stronger acid

1

(so 0.01 mol/dm^3) methanoic acid has a higher concentration of hydrogen ions

1

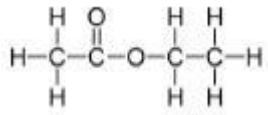
(therefore) more collisions per unit time

1

(e) ethyl ethanoate

1

(f)



1

[12]

Q7.

(a) **test:** (use a) glowing splint

*do **not** accept burning splint*

1

result: relights

dependent on correct test in MP1
ignore with a pop

1

(b) starch

1

cellulose

allow glycogen

1

(c) 2

1

(d) water

allow H_2O

1

(e) ammonia

1

nitrogen

*if no other mark awarded, allow **1** mark for NO / NO_2 / N_2O / NO_x or equivalent named compounds*

1

(f) two polymer chains

allow two polymer strands

1

four (different) monomers / nucleotides

allow four (different) bases
allow cytosine, guanine, adenine and thymine
allow C G A T

1

(double) helix

allow spiral
*if no other mark awarded, allow **1** mark for DNA*

1

[11]