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CHEMISTRY

0620/31

Paper 3 Theory (Core)

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Blank pages are indicated.

1 (a) A list of symbols and formulae is shown.



Answer the following questions about these symbols and formulae.
Each symbol or formula may be used once, more than once or not at all.

Which symbol or formula represents:

(i) a compound which contributes to acid rain

..... [1]

(ii) a compound which is a product of respiration

..... [1]

(iii) a gas which forms 21% of clean dry air

..... [1]

(iv) an ion which forms a red-brown precipitate when added to aqueous sodium hydroxide

..... [1]

(v) an ion formed when an atom gains electrons?

..... [1]

- (b) Complete the table to show the relative charge and approximate relative mass of a proton, a neutron and an electron.

type of particle	relative charge	approximate relative mass
proton	+1	
neutron		
electron		$\frac{1}{2000}$

[3]

- (c) Deduce the number of electrons and neutrons in an atom of the isotope of iron shown.



number of electrons

number of neutrons

[2]

[Total: 10]

Question no. 1

(a) Using the list of symbols and formulae

You are choosing from: Al^{3+} , CH_4 , CO_2 , Fe^{3+} , N_2 , NO_2 , O_2 , O^{2-} , Zn^{2+} .

(i) A compound which contributes to acid rain $\rightarrow \text{NO}_2$

Nitrogen dioxide, **NO_2** , is an acidic oxide. In the atmosphere it can dissolve in rainwater and react to form acids (such as nitric acid), so it **contributes to acid rain**.

(ii) A compound which is a product of respiration $\rightarrow \text{CO}_2$

In aerobic respiration, organisms release **carbon dioxide, CO_2** , as a waste product when glucose is oxidised.

(iii) A gas which forms 21% of clean dry air $\rightarrow \text{O}_2$

Clean dry air contains about **21% oxygen**, so the correct gas is **O_2** .

(iv) An ion which forms a red-brown precipitate when added to aqueous sodium hydroxide $\rightarrow \text{Fe}^{3+}$

Fe^{3+} (iron(III) ions) react with hydroxide ions (from aqueous sodium hydroxide) to form **iron(III) hydroxide, $\text{Fe}(\text{OH})_3$** , which appears as a **red-brown precipitate**.

(v) An ion formed when an atom gains electrons $\rightarrow \text{O}^{2-}$

When an atom **gains electrons**, it becomes a **negative ion (anion)**. From the list, **O^{2-}** is formed when an oxygen atom gains **two electrons**.

So the final answers are:

- (i) **NO_2**
- (ii) **CO_2**
- (iii) **O_2**
- (iv) **Fe^{3+}**
- (v) **O^{2-}**

(b) Relative charge and approximate relative mass

A proton and neutron are both much heavier than an electron, and they have almost the same mass.

- **Proton:** relative charge **+1**, approximate relative mass **1**
- **Neutron:** relative charge **0**, approximate relative mass **1**
- **Electron:** relative charge **-1**, approximate relative mass **1/2000** (already shown)

So you would complete the table with:

- proton mass: **1**
- neutron charge: **0**
- neutron mass: **1**
- electron charge: **-1**

(c) Electrons and neutrons in the isotope of iron shown, $^{58}_{26}\text{Fe}$

For $^{58}_{26}\text{Fe}$:

- The **atomic number is 26**, meaning there are **26 protons**.
- A neutral atom has **equal numbers of protons and electrons**, so the **number of electrons = 26**.
- The **mass number is 58**, which equals **protons + neutrons**.
So **neutrons = 58 - 26 = 32**.

Number of electrons = 26

Number of neutrons = 32

- 2 A solution is obtained by filtering a mixture of soil and water. The table shows the mass of some of the ions in 1000 cm^3 of this solution.

name of ion	formula of ion	mass of ion in 1000 cm^3 of soil solution / mg
aluminium	Al^{3+}	0.1
	NH_4^+	35.0
calcium	Ca^{2+}	1.3
iron(II)	Fe^{2+}	47.0
magnesium	Mg^{2+}	0.2
	NO_3^-	23.0
phosphate	PO_4^{3-}	4.2
potassium	K^+	99.0
sulfate	SO_4^{2-}	7.5

- (a) Answer these questions using the information in the table.

(i) Which negative ion has the lowest concentration?

..... [1]

(ii) State the name of the NO_3^- ion.

..... [1]

(iii) Calculate the mass of phosphate ions in 250 cm^3 of this solution.

mass = mg [1]

(iv) Name the compound that contains NH_4^+ ions and PO_4^{3-} ions.

..... [1]

- (b) Describe a test for potassium ions.

test

observations

[2]

(c) The names and formulae for some compounds are shown.

aluminium phosphate, AlPO_4

calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$

potassium phosphate, K_3PO_4

Deduce the formula for magnesium phosphate.

..... [1]

[Total: 7]

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Question no. 2

(a)(i) Which negative ion has the lowest concentration?

From the table, the **negative ions (anions)** listed are **nitrate (NO_3^-)**, **phosphate (PO_4^{3-})**, and **sulfate (SO_4^{2-})**. Their masses in 1000 cm^3 are **23.0 mg**, **4.2 mg**, and **7.5 mg** respectively. The smallest value is **4.2 mg**, so the anion with the lowest concentration is **phosphate, PO_4^{3-}** .

Answer: phosphate (PO_4^{3-})

(a)(ii) State the name of the NO_3^- ion.

The ion NO_3^- is called **nitrate**.

Answer: nitrate

(a)(iii) Calculate the mass of phosphate ions in 250 cm^3 of this solution.

The table gives the mass of phosphate ions in 1000 cm^3 as **4.2 mg**.

Since **250 cm^3 is one quarter of 1000 cm^3** , the mass in 250 cm^3 will be one quarter of 4.2 mg:

- $4.2 \div 4 = 1.05 \text{ mg}$

Mass of phosphate ions in $250 \text{ cm}^3 = 1.05 \text{ mg}$

(a)(iv) Name the compound that contains NH_4^+ ions and PO_4^{3-} ions.

A compound made from **NH_4^+ (ammonium)** and **PO_4^{3-} (phosphate)** is named by writing the cation first, then the anion:

Answer: ammonium phosphate

(b) Describe a test for potassium ions.

A standard test for potassium ions is a **flame test**.

Test: Clean a nichrome/platinum wire loop by dipping it in hydrochloric acid and heating in a Bunsen flame until no colour is seen. Dip the loop into the sample solution, then place it back into the edge of a non-luminous flame.

Observation: Potassium ions produce a lilac (pale purple) flame.

- ✓ **Test: flame test**
 - ✓ **Observation: lilac flame**
-

(c) Deduce the formula for magnesium phosphate.

Magnesium forms Mg^{2+} ions and phosphate is PO_4^{3-} . To make the total charge zero, we need the lowest common multiple of 2 and 3, which is 6:

- 3 magnesium ions give $3 \times (+2) = +6$
- 2 phosphate ions give $2 \times (-3) = -6$

So the neutral formula is:

- ✓ **$\text{Mg}_3(\text{PO}_4)_2$**

3 Many compounds and elements have important uses.

(a) Complete the table to show the name, formula and use of each compound and element.

name of compound or element	number of atoms in the formula	formula	use
chlorine	chlorine = 2	Cl_2	
	carbon = 1 hydrogen = 4	CH_4	
calcium carbonate	calcium = 1 carbon = 1 oxygen = 3		

[5]

(b) The table shows the minimum temperature for the reduction of four metal oxides by carbon.

metal oxide	minimum temperature for reduction by carbon
calcium oxide	not reduced at $1530^\circ C$
iron(II) oxide	reduced at $650^\circ C$
titanium oxide	reduced at $1530^\circ C$
zinc oxide	reduced at $720^\circ C$

Put the four metals in order of their reactivity.

Put the least reactive metal first.

least reactive \longrightarrow most reactive

--	--	--	--

[2]

(c) Anhydrous copper(II) sulfate, CuSO_4 , is used to test for water.

(i) Describe the change in colour when water is added to anhydrous copper(II) sulfate.

from to [2]

(ii) This reaction is reversible.

Describe how this reaction can be reversed.

..... [1]

(iii) State **one** use of water in industry.

..... [1]

[Total: 11]

Question no. 3

(a) Completing the table (name, formula and use)

Chlorine is a diatomic element, so it exists as molecules with **two chlorine atoms: Cl_2** . A common use of chlorine is **treating water** (it acts as a disinfectant to **kill bacteria and other microorganisms**), so it is used in **drinking-water and swimming-pool treatment**.

The formula **CH_4** (with **carbon = 1** and **hydrogen = 4**) is the compound **methane**. Methane is widely used as a **fuel** (it is the main component of natural gas), because it **burns in oxygen to release energy**.

For **calcium carbonate**, the numbers given (**calcium = 1, carbon = 1, oxygen = 3**) mean the formula is **CaCO_3** . Calcium carbonate is used in several important ways, for example **making cement, iron extraction** (as limestone in a blast furnace), or **neutralising acidic soil** (liming). Any one of these is acceptable.

So the missing entries are:

- **Chlorine (Cl_2): use = treating water / killing bacteria**
- **Name for CH_4 = methane; use = fuel**
- **Formula for calcium carbonate = CaCO_3 ; use = making cement / iron extraction / neutralising acidic soil**

(b) Ordering the metals by reactivity (least reactive first)

This table tells you how easily each metal oxide is reduced by carbon. **If an oxide is reduced by carbon at a lower temperature, the metal is less reactive** (because it holds onto oxygen less strongly). **If it needs a very high temperature, the metal is more reactive**. If it **cannot be reduced by carbon even at 1530°C** , the metal is **more reactive than carbon** (so carbon cannot remove its oxygen).

- **Iron(II) oxide reduced at 650°C → iron is the least reactive here.**
- **Zinc oxide reduced at 720°C → zinc is more reactive than iron.**
- **Titanium oxide reduced at 1530°C → titanium is more reactive than zinc.**
- **Calcium oxide not reduced at 1530°C → calcium is the most reactive.**

So the correct order is:

iron < zinc < titanium < calcium

(c) Anhydrous copper(II) sulfate test for water

(i) Colour change when water is added

Anhydrous copper(II) sulfate is **white**. When water is added it becomes hydrated copper(II) sulfate, which is **blue**.

So the change is:

from white to blue

(ii) Reversing the reaction

Because it is reversible, you can reverse it by **removing the water**. The practical way is to **heat the blue hydrated copper(II) sulfate** so the water of crystallisation is driven off, turning it back **white** (anhydrous).

So: **heat it**.

(iii) One use of water in industry

One acceptable example is that water is used as a **coolant** (for example, in power stations and industrial processes to remove heat). Another acceptable answer is **as a solvent** in chemical manufacture.

A clear one-mark answer: **water is used as a coolant**.

4 The properties of five alkenes at room temperature are shown in the table.

alkene	number of carbon atoms in a molecule	state at room temperature	density in g/cm ³	boiling point /°C
ethene	2	gas	0.0012	-104
propene	3	gas	0.0018	-47
butene	4	gas	0.0024	
pentene	5	liquid	0.64	30
hexene	6	liquid	0.67	63

(a) Answer these questions using only the information in the table.

(i) Predict the boiling point of butene.

..... °C [1]

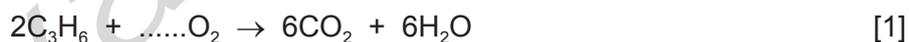
(ii) Describe the general trend in the density of the alkenes.

..... [1]

(iii) Suggest why the densities of the first three alkenes are much lower than the density of pentene and hexene.

..... [1]

(b) (i) Complete the chemical equation for the complete combustion of propene.



(ii) Describe a test for carbon dioxide.

test

observations

[2]

(iii) Universal indicator is added to an aqueous solution of carbon dioxide.

- What colour change is observed?

from green to

- Give a reason for your answer.

.....

.....

[2]

(c) When propene undergoes incomplete combustion, carbon monoxide is formed.

(i) What condition is needed for incomplete combustion?

.....
..... [1]

(ii) Give **one** adverse effect of carbon monoxide on health.

..... [1]

[Total: 10]

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Question no. 4

(a)(i) Predict the boiling point of butene (using only the table)

From the table, as the number of carbon atoms increases, the **boiling point increases**: ethene is **-104 °C**, propene is **-47 °C**, and pentene is **30 °C**. Butene (4 carbons) must therefore have a boiling point **between -47 °C and 30 °C**. A sensible prediction is **about -6 °C** (any value in that range would fit the pattern).

Predicted boiling point of butene: -6 °C

(a)(ii) Describe the general trend in the density of the alkenes

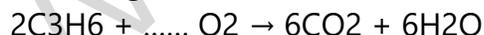
Looking down the table, the densities go up as the molecules get larger: **0.0012 → 0.0018 → 0.0024 → 0.64 → 0.67**. So the general trend is that **density increases as the number of carbon atoms increases** (i.e. as the alkene chain gets longer).

(a)(iii) Suggest why the first three alkenes have much lower densities than pentene and hexene

The table shows that the first three alkenes (ethene, propene, butene) are **gases at room temperature**, whereas pentene and hexene are **liquids**. **Gases have much lower densities than liquids** because their particles are much further apart, so there is far less mass in the same volume.

(b)(i) Complete the equation for the complete combustion of propene

You are given:



On the right side there are **6CO₂**, which contains **12 oxygen atoms**, and **6H₂O**, which contains **6 oxygen atoms**. Total oxygen atoms needed = **18**, so that is **9 molecules of O₂**.



(b)(ii) Describe a test for carbon dioxide

Test: Bubble the gas through **limewater (aqueous calcium hydroxide)**.

Observation: The limewater **turns milky/cloudy** (a **white precipitate** forms).

(b)(iii) Universal indicator is added to aqueous carbon dioxide

Colour change: from **green to yellow**.

Reason: Carbon dioxide dissolves in water to form an **acidic solution** (carbon dioxide is an **acidic oxide**), so the pH drops below 7 and universal indicator shifts toward **yellow**.

(c)(i) Condition needed for incomplete combustion (forming carbon monoxide)

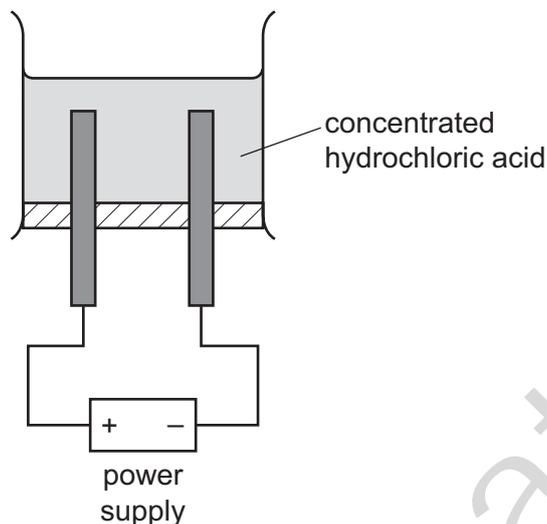
Incomplete combustion happens when there is **limited oxygen** (insufficient oxygen supply).

(c)(ii) One adverse effect of carbon monoxide on health

Carbon monoxide is **poisonous/toxic** because it binds strongly to haemoglobin and **reduces oxygen transport in the blood**, which can cause **unconsciousness and death**.

5 When concentrated hydrochloric acid is electrolysed, gases are produced at the electrodes.

The incomplete apparatus is shown.



(a) (i) Complete the diagram by:

- labelling the anode and cathode
- showing how the gases are collected.

[2]

(ii) Predict the products of this electrolysis at the:

positive electrode

negative electrode

[2]

(iii) Graphite (carbon) electrodes are used in this electrolysis.

Suggest **one** other element that can be used as an electrode and give a reason, other than that it can conduct electricity.

element

reason

[2]

(b) Hydrogen chloride is produced when chlorine reacts with hydrogen.

Complete the chemical equation for this reaction.



(c) Aqueous chlorine reacts with aqueous sodium iodide.



(i) How does this reaction show that chlorine is more reactive than iodine?

..... [1]

(ii) What colour is iodine in aqueous solution?

..... [1]

[Total: 10]

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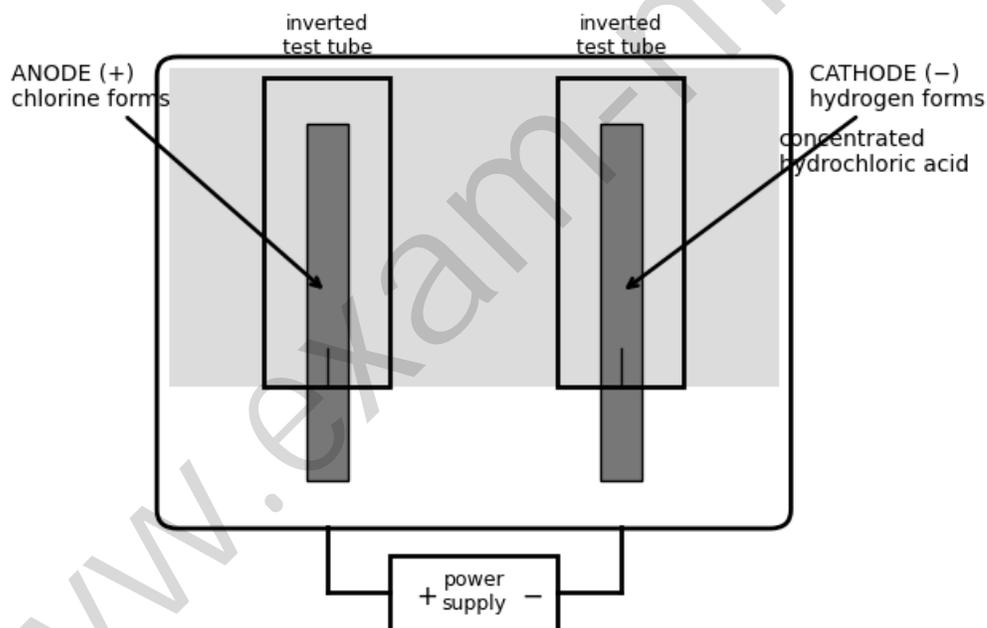
Question no. 5

(a)(i) Completing the apparatus (labels + gas collection)

In this electrolytic cell, the electrode connected to the **positive terminal** of the power supply is the **anode (+)**, and the electrode connected to the **negative terminal** is the **cathode (-)**.

From the circuit shown, the **left electrode is the anode (+)** and the **right electrode is the cathode (-)**.

To **collect the gases**, you place an **inverted test tube (or inverted measuring cylinder)** over **each electrode**, with the **open end dipping below the surface of the hydrochloric acid**. This traps the gas as it bubbles up, so it displaces the liquid inside the tube and can be collected.



(a)(ii) Products at each electrode

At the **positive electrode (anode)**, oxidation happens. In concentrated hydrochloric acid there are lots of **chloride ions, Cl^-** , so these are preferentially discharged to form chlorine gas:

Positive electrode (anode): chlorine gas, Cl₂

At the **negative electrode (cathode)**, reduction happens. **Hydrogen ions (H⁺)** gain electrons to form hydrogen gas:

Negative electrode (cathode): hydrogen gas, H₂

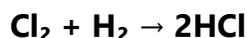
(a)(iii) One other element for an electrode + reason (not "it conducts")

Element: platinum

Reason: Platinum is **chemically inert / unreactive**, so it **does not react with concentrated hydrochloric acid** and **does not get used up** during electrolysis.

(b) Equation for hydrogen + chlorine forming hydrogen chloride

Chlorine reacts with hydrogen to form hydrogen chloride gas. Balancing gives:



(c)(i) How this shows chlorine is more reactive than iodine

Because **chlorine displaces iodine** from sodium iodide: chlorine reacts with **iodide ions (I⁻)** and forms **iodine (I₂)**, taking iodine's place in the salt to make **sodium chloride**. This displacement shows chlorine is **more reactive** than iodine.

(c)(ii) Colour of iodine in aqueous solution

Iodine in aqueous solution is **brown**.

6 Acids have characteristic properties.

(a) Hydrochloric acid reacts with magnesium.

Name the products of this reaction and give the observations.

.....

.....

.....

.....

.....

..... [4]

(b) The rate of reaction of iron(II) carbonate with hydrochloric acid can be determined by measuring the time taken to produce 20 cm³ of carbon dioxide.

A student measured the time taken to produce 20 cm³ of carbon dioxide at three different temperatures.

In each experiment the student used:

- 1 g of large pieces of iron(II) carbonate
- dilute hydrochloric acid of the same concentration and volume.

The results are shown in the table.

temperature /°C	time /s
20	38
25	30
30	19

(i) Use the information in the table to describe how the rate of reaction changes with temperature.

..... [1]

(ii) Describe the effect of each of the following on the rate of this reaction at constant temperature.

- Smaller pieces of iron(II) carbonate are used.

All other conditions stay the same.

.....

- The concentration of hydrochloric acid is decreased.

All other conditions stay the same.

.....

[2]

(c) The reaction of iron(II) carbonate with hydrochloric acid is exothermic.

What is meant by the term *exothermic*?

..... [1]

(d) Rust contains compounds of iron.

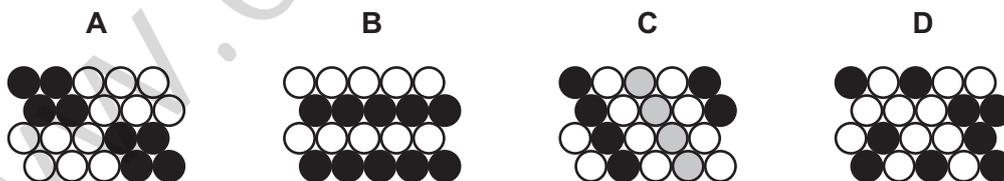
State **two** conditions needed for iron to rust.

.....

..... [2]

(e) Iron and magnesium are both used in alloys.

Which **one** of these diagrams, **A**, **B**, **C** or **D**, best represents an alloy?



..... [1]

[Total: 11]

Question no. 6

(a) Reaction of hydrochloric acid with magnesium

When **magnesium reacts with hydrochloric acid**, a **salt and hydrogen gas** are formed. Specifically, the products of the reaction are **magnesium chloride** and **hydrogen gas**.

During the reaction, **bubbles of gas are produced**, showing **effervescence** as **hydrogen gas is released**. The **magnesium metal gradually disappears or becomes smaller** as it reacts and is used up. In addition, the reaction mixture **gets warm**, showing that the reaction is **exothermic** and releases heat to the surroundings.

(b)(i) Effect of temperature on rate of reaction

From the table, as the **temperature increases**, the **time taken to produce 20 cm³ of carbon dioxide decreases**. For example, it takes **38 seconds at 20 °C**, **30 seconds at 25 °C**, and only **19 seconds at 30 °C**. This shows that **increasing temperature increases the rate of reaction**, because the same amount of gas is produced in a shorter time.

(b)(ii) Effect of changing conditions at constant temperature

If **smaller pieces of iron(II) carbonate** are used, the **rate of reaction increases**. This is because smaller pieces have a **larger surface area**, allowing **more frequent collisions** between the acid particles and the carbonate, so carbon dioxide is produced more quickly.

If the **concentration of hydrochloric acid is decreased**, the **rate of reaction decreases**. This is because there are **fewer acid particles per unit volume**, resulting in **fewer successful collisions** with the iron(II) carbonate each second.

(c) Meaning of exothermic

An **exothermic reaction** is a reaction that **releases heat energy to the surroundings**, causing the **reaction mixture to become warmer**.

(d) Conditions needed for iron to rust

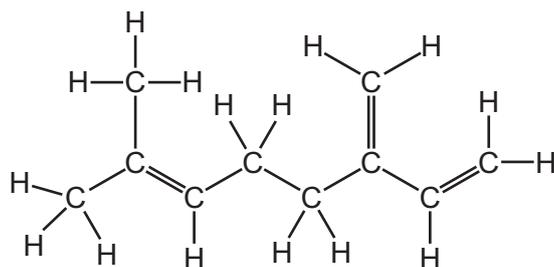
For iron to rust, **both water and oxygen** must be present. Rusting does not occur if either **water** or **oxygen (air)** is absent.

(e) Diagram that best represents an alloy

The correct diagram is **D**.

This diagram best represents an **alloy** because it shows **different types of atoms mixed together in an irregular arrangement**, rather than identical atoms arranged in neat layers. This reflects the structure of alloys, where atoms of different elements disrupt the regular lattice of a pure metal.

7 The structure of myrcene is shown.



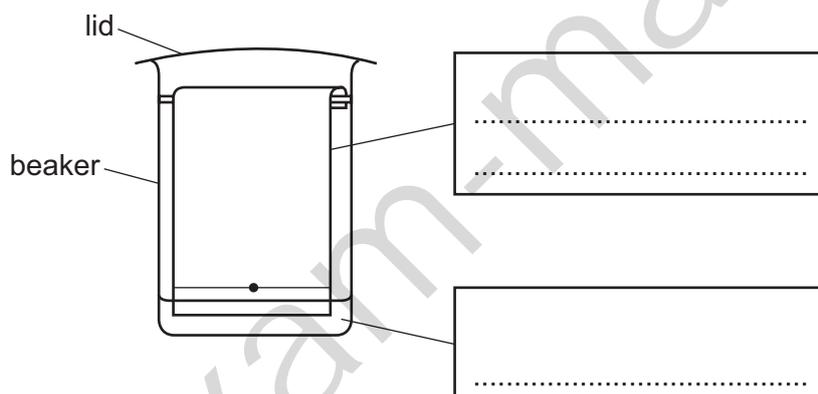
(a) Deduce the formula of myrcene to show the number of atoms of carbon and hydrogen.

..... [1]

(b) Myrcene is found in some plants.

The coloured compounds in plant leaves can be separated by chromatography.

Complete the diagram by putting the correct labels in the boxes.



[2]

(c) Myrcene is an unsaturated hydrocarbon.

Describe a chemical test to distinguish between a saturated and an unsaturated hydrocarbon.

test

observations with saturated hydrocarbon

observations with unsaturated hydrocarbon

[3]

(d) Butane is a saturated hydrocarbon.

To which homologous series does butane belong?

Draw a circle around the correct answer.

alcohol alkane alkene carboxylic acid [1]

(e) Large hydrocarbons can be cracked to form smaller hydrocarbons.

Complete the chemical equation for cracking tridecane, $C_{13}H_{28}$, to form an alkene and one other hydrocarbon.



(f) Ethene is an alkene.

Draw the structure of ethene showing all of the atoms and all of the bonds.

[1]

(g) Complete the sentences about the separation of hydrocarbons from petroleum using words from the list.

bitumen combustion condense crystallisation distillation

evaporate gasoline kerosene melt

Hydrocarbons are separated in a fractionating column by fractional

Hydrocarbons with lower boiling points move further up the column. When the temperature

in the column falls below the boiling points of the hydrocarbons they The

fraction at the bottom of the column which is used for making roads is called

[3]

[Total: 12]

Question no. 7

(a) Formula of myrcene

From the displayed structure, you can **count the atoms directly**. There are **10 carbon atoms** in total, and when you count all the hydrogens shown (including those attached to the ends and on the double-bond carbons), there are **16 hydrogen atoms**. So the molecular formula is **C₁₀H₁₆**.

(b) Chromatography apparatus labels

In the diagram:

- The **top box** points to the sheet hanging down inside the beaker → this is the **chromatography paper (or filter paper)**.
- The **bottom box** points to the liquid at the bottom → this is the **solvent** (for example **alcohol/ethanol**, depending on what is used).

So: **top: chromatography paper, bottom: solvent**.

(c) Test to distinguish saturated vs unsaturated hydrocarbon

A simple chemical test is to use **bromine water (aqueous bromine)**.

Test: Add a few drops of **bromine water** to the hydrocarbon and **shake** (preferably in the absence of UV light so substitution doesn't confuse results).

Observation with a saturated hydrocarbon: The bromine water shows **no colour change** and **stays orange/brown**, because a saturated hydrocarbon has **only single C-C bonds** so it does not react by addition under these conditions.

Observation with an unsaturated hydrocarbon: The bromine water is **decolourised (turns colourless)**, because the **C=C double bond** reacts with bromine in an **addition reaction**, removing the coloured bromine from solution.

(d) Homologous series of butane

Butane is a saturated hydrocarbon containing **only single bonds**, so it belongs to the **alkane** homologous series.

Correct answer: **alkane**.

(e) Cracking tridecane, C₁₃H₂₈

You are told one product is the alkene **C₃H₆**. The other product must use up the remaining atoms.

Start with **C₁₃H₂₈** and subtract **C₃H₆**:

- Carbons left: $13 - 3 = 10$
- Hydrogens left: $28 - 6 = 22$

So the other hydrocarbon is **C₁₀H₂₂**.

Completed equation: **C₁₃H₂₈ → C₃H₆ + C₁₀H₂₂**

(f) Displayed structure of ethene (all atoms and bonds)

Ethene has the formula **C₂H₄** and contains a **C=C double bond**, with **two H atoms attached to each carbon**.

Here is a clear displayed formula as an actual image:

Ethene (C₂H₄) displayed formula



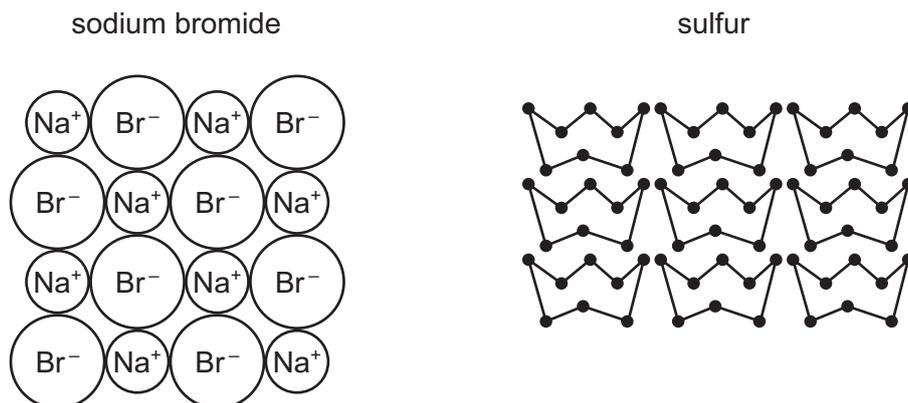
(g) Separation of hydrocarbons from petroleum (fill in the blanks)

Hydrocarbons are separated in a fractionating column by fractional **distillation**.

Hydrocarbons with lower boiling points move further up the column. When the temperature in the column falls below the boiling points of the hydrocarbons they **condense**.

The fraction at the bottom of the column which is used for making roads is called **bitumen**.

8 The diagram shows part of the structures of sodium bromide and sulfur.



(a) Describe both sodium bromide and sulfur in terms of:

- bonding

.....

.....

.....

.....

- electrical conductivity

.....

.....

- solubility in water.

.....

.....

[5]

(b) Sulfur is an element.

What is meant by the term *element*?

.....

.....

[1]

(c) Sodium can be extracted from sodium bromide by electrolysis.

Sodium is a metal in Group I of the Periodic Table.

(i) Describe **one** chemical property of sodium.

..... [1]

(ii) Which **two** of these statements about the physical properties of sodium are correct?

Tick **two** boxes.

Sodium is very hard.

Sodium has a high density.

Sodium conducts electricity.

Sodium is malleable.

Sodium does not conduct heat.

[2]

[Total: 9]

Question no. 8

(a) Description of sodium bromide and sulfur

Bonding

Sodium bromide has ionic bonding. Each sodium atom loses one electron to form a **Na⁺ ion**, while each bromine atom gains one electron to form a **Br⁻ ion**. These oppositely charged ions are held together by **strong electrostatic attractions** acting in all directions within a **giant ionic lattice**.

Sulfur has covalent bonding within molecules. Each sulfur atom forms **covalent bonds** with other sulfur atoms, producing discrete **S₈ molecules**. Although the covalent bonds within each molecule are strong, the forces between separate sulfur molecules are **weak intermolecular forces**.

Electrical conductivity

Solid sodium bromide does not conduct electricity because the ions are fixed in position within the lattice and cannot move. However, **molten sodium bromide or sodium bromide dissolved in water does conduct electricity**, as the **Na⁺ and Br⁻ ions are free to move and carry charge**.

Sulfur does not conduct electricity in any state because it consists of neutral molecules and **has no free ions or delocalised electrons** to carry an electric current.

Solubility in water

Sodium bromide is soluble in water because water molecules surround and stabilise the **Na⁺ and Br⁻ ions**, allowing the ionic lattice to break apart.

Sulfur is insoluble in water because it is a **non-polar molecular substance** and does not interact strongly with polar water molecules.

(b) Meaning of the term *element*

An **element** is a substance that **contains only one type of atom** and **cannot be broken down into simpler substances by chemical means**.

(c) Sodium and its properties

(i) One chemical property of sodium

Sodium reacts vigorously with water, producing sodium hydroxide and hydrogen gas.

(ii) Correct physical properties of sodium

The two correct statements are:

- **Sodium conducts electricity**, because it is a metal with **delocalised electrons**.
- **Sodium is malleable**, meaning it can be hammered or shaped without breaking.

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The Periodic Table of Elements

		Group							
I	II	III	IV	V	VI	VII	VIII		
3 Li lithium 7	4 Be beryllium 9	1 H hydrogen 1	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20	2
11 Na sodium 23	12 Mg magnesium 24	Key atomic number atomic symbol name relative atomic mass		13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195
87 Fr francium —	88 Ra radium —	89–103 actinoids	104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —
							111 Rg roentgenium —	112 Cn copernicium —	81 Tl thallium 204
							82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —
							85 At astatine —	86 Rn radon —	51 Sb antimony 122
							52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
							50 Sn tin 119	51 Sb antimony 122	87 Kr krypton 84
							49 In indium 115	48 Cd cadmium 112	33 As arsenic 75
							47 Ag silver 108	46 Pd palladium 106	34 Se selenium 79
							29 Cu copper 64	28 Ni nickel 59	35 Br bromine 80
							27 Co cobalt 59	26 Fe iron 56	36 Kr krypton 84
							25 Mn manganese 55	24 Cr chromium 52	37 Kr krypton 84
							23 V vanadium 51	22 Ti titanium 48	38 Kr krypton 84
							21 Sc scandium 45	20 Ca calcium 40	39 Kr krypton 84
							19 K potassium 39	18 Ar argon 40	40 Kr krypton 84
							17 Cl chlorine 35.5	16 S sulfur 32	41 Kr krypton 84
							15 P phosphorus 31	14 Si silicon 28	42 Kr krypton 84
							13 Al aluminium 27	12 Mg magnesium 24	43 Kr krypton 84
							11 Na sodium 23	10 Ne neon 20	44 Kr krypton 84
							10 Ne neon 20	9 F fluorine 19	45 Kr krypton 84
							9 F fluorine 19	8 O oxygen 16	46 Kr krypton 84
							8 O oxygen 16	7 N nitrogen 14	47 Kr krypton 84
							7 N nitrogen 14	6 C carbon 12	48 Kr krypton 84
							6 C carbon 12	5 B boron 11	49 Kr krypton 84
							5 B boron 11	4 Be beryllium 9	50 Kr krypton 84
							4 Be beryllium 9	3 Li lithium 7	51 Kr krypton 84

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).