

## Investigating the combustion of alcohols

Different fuels have different energy densities. The combustion of alcohol is an exothermic reaction in which water, carbon dioxide and heat energy are produced. You can compare the energy density of alcohols by using the subsequent heat produced to heat water.

6. Formulate a hypothesis for the relationship between the energy density of alcohols and the length of their carbon chain. Explain this using scientific reasoning. [3]
7. Design an experiment to test your hypothesis using some or all of the materials listed. You should include:
  - a) the method; include a drawing of your apparatus
  - b) the dependent, independent and control variables
  - c) any safety precautions required
  - d) a table for recording and analyzing results. [10]

### Equipment

- The following alcohols:
  - methanol ( $\text{CH}_3\text{OH}$ )
  - ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ )
  - propan-1-ol ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ )
  - butan-1-ol ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ )
- Spirit burner
- Electronic balance
- Aluminium drinks can
- Thermometer or temperature probe
- Clamp stand and clamp
- 100 cm<sup>3</sup> measuring cylinder
- Distilled water

## Investigating acid rain

Sulfur dioxide,  $\text{SO}_2$ , is emitted into the atmosphere both naturally (volcanoes) and as a consequence of human activities (combustion of fossil fuels). The mixing of this toxic gas with water is the cause of acid deposition.

6. Design a way of simulating acid rain formation by sulfur pollutants and investigate the effects of this pollutant on the pH of water. You could use the following points for guidance. [10]

### Equipment

- sulfur powder
- sodium hydrogencarbonate
- universal indicator solution
- a deflagration spoon
- bunsen burner
- gas jar
- distilled water.

Your design should include:

- how you will generate the sulfur dioxide gas
- the method used to enable the sulfur dioxide to dissolve in the distilled water
- how you will test to see if there has been a change in the pH of the solution
- details of the variables being kept constant during the experiment
- details of the safety issues and how you will minimize any risks.

7. Propose a research question for your investigation. [2]
8. Formulate a testable hypothesis and explain it using scientific reasoning. [4]



## Modelling global warming

Global warming can be defined as the actual and predicted increases in temperature of the Earth's atmosphere and oceans. The predictions are based on many types of evidence collected around the world by the scientific community.

Consider how you could use the following equipment to model global warming and the effect of the increasing amount of greenhouse gases in the atmosphere:

- three digital temperature probes/software or three glass thermometers
- three 1.5 litre soda bottles

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- rubber bungs with a hole for the temperature probes/thermometers
- distilled water
- antacid tablets (when these are dissolved in water they produce carbon dioxide)
- high-capacity heat lamp
- 1 m ruler
- stopwatch.

**6.** Formulate a testable hypothesis. [3]

**7.** Design an experiment to test your hypothesis. The method should include:

- the independent and dependent variables, and other variables being controlled
- how you plan to record your quantitative and qualitative observations. [10]

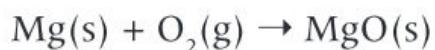
Calculate the number of moles in each of the following masses:

- a)** 9.8 g of sulfuric acid,  $\text{H}_2\text{SO}_4$
- b)** 25.0 g of calcium carbonate,  $\text{CaCO}_3$
- c)** 8.0 g of sodium hydroxide,  $\text{NaOH}$
- d)** 60 g of glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$

Calculate the mass (in grams) in each of the following:

- a)** 0.25 mol of carbon dioxide,  $\text{CO}_2$
- b)** 3 mol of ammonia,  $\text{NH}_3$
- c)** 0.710 mol of calcium phosphate,  $\text{Ca}_3(\text{PO}_4)_2$
- d)** 0.211 mol of iron(III) oxide,  $\text{Fe}_2\text{O}_3$

Magnesium burns in the presence of oxygen to form the metal oxide, magnesium oxide. This oxidation reaction is commonly performed in a school laboratory. A student weights out 18.0 g of magnesium for the reaction. The equation for the reaction is as follows:

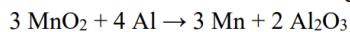


- a)** Balance the chemical equation.
- b)** Calculate the number of moles of the reactant, magnesium.
- c)** If oxygen is in excess and all the magnesium is used up, calculate the number of moles of magnesium oxide formed.
- d)** What mass of magnesium oxide is produced?

What mass of barium sulfate would be produced when 10 g of barium chloride is completely consumed in the following reaction?



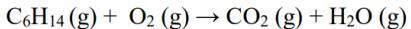
1. Manganese (IV) oxide reacts with aluminum to form elemental manganese and aluminum oxide:



What mass of Al is required to completely react with 25.0 g MnO<sub>2</sub>?

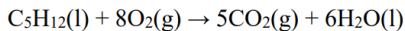
- a) 7.76 g Al
- b) 5.82 g Al
- c) 33.3 g Al
- d) 10.3 g Al

2. Consider the unbalanced equation for the combustion of hexane:



Balance the equation and determine how many moles of O<sub>2</sub> are required to react completely with 7.2 moles of C<sub>6</sub>H<sub>14</sub>.

3. How many moles of CO<sub>2</sub> are produced when 3 moles of pentane react with excess oxygen



- a) 5 moles
- b) 3/5 moles
- c) 15 moles
- d) 3 moles

4. The overall equation involved in photosynthesis is      6 CO<sub>2</sub> + 6 H<sub>2</sub>O → C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> + 6 O<sub>2</sub>.

How many grams of glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, 180.1 g/mol) form when 4.40 g of CO<sub>2</sub> react?

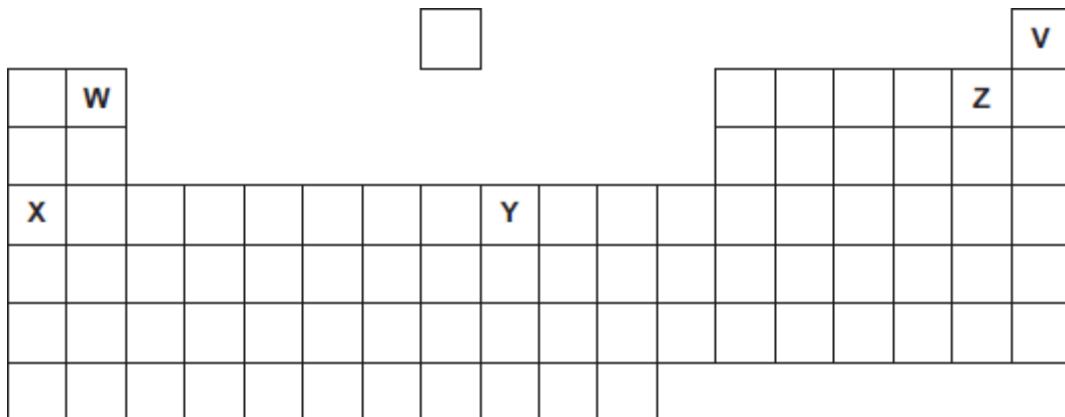
- a) 18.0 g
- b) 3.00 g
- c) 108 g
- d) 0.0167 g

**MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks**

**Q1.**

Five elements, **V**, **W**, **X**, **Y** and **Z**, are shown in the periodic table.

The letters are **not** the chemical symbols of the five elements.



Use the correct letter, **V**, **W**, **X**, **Y** or **Z**, to answer each question.

- (a) Which element is a transition metal?

(1)

- (b) Which element is in Group 2?

(1)

- (c) Which element is a noble gas?

(1)

- (d) Which element has an atomic (proton) number of 4?

(1)

- (e) Which element forms only 1+ ions?

(1)

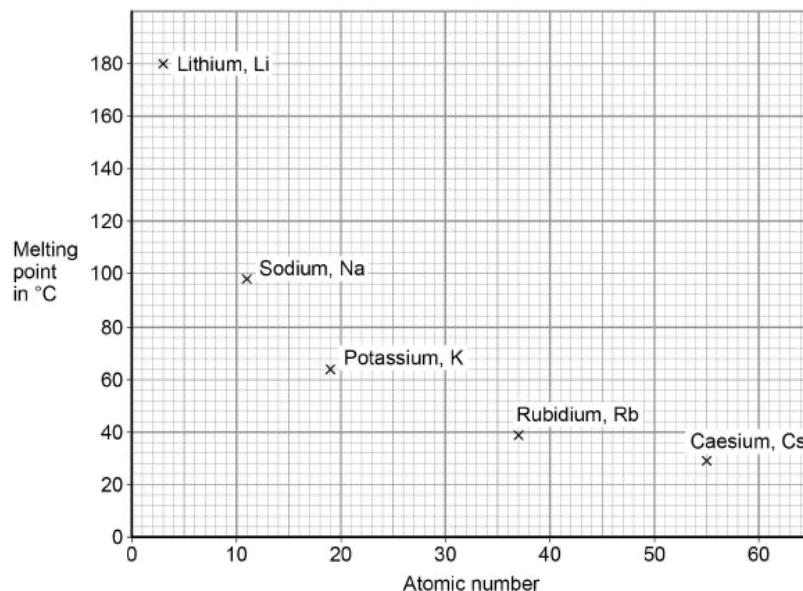
**(Total 5 marks)**

## MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks

### Q2.

This question is about Group 1 metals.

The graph below shows the melting points of Group 1 metals plotted against their atomic number.



- (a) Describe the trend shown by the melting points of Group 1 metals as the atomic number increases.

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(1)

- (b) Determine the atomic number and melting point of caesium.

Use the graph above.

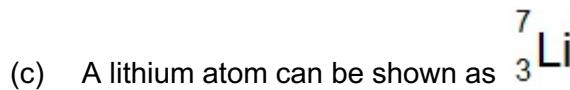
Atomic number of caesium = \_\_\_\_\_

Melting point of caesium = \_\_\_\_\_ °C

(1)

**MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks**

Lithium is a Group 1 metal.



How many electrons does the **outer shell** of a lithium atom contain?

Tick **one** box.

1

3

4

7

(1)

(d) Lithium reacts with oxygen to produce lithium oxide.

Draw **one** line from each substance to the correct description of the substance.

**Substance****Description**

compound

Lithium oxide

element

metal

Oxygen

mixture

polymer

(2)

(e) Balance the equation for the reaction of lithium with oxygen.



(1)

**MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks**

- (f) What type of bonding is present in lithium oxide?

Tick **one** box.

Covalent

Ionic

Metallic

(1)

- (g) Calculate the relative formula mass ( $M_r$ ) of lithium oxide ( $\text{Li}_2\text{O}$ ).

Relative atomic masses ( $A_r$ ): Li = 7 O = 16

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Relative formula mass = \_\_\_\_\_

(2)

**(Total 9 marks)**

**Q3.**

This question is about the periodic table.

In 1864 John Newlands suggested an arrangement of elements.

**Figure 1** shows the arrangement Newlands suggested.

**Figure 1**

1	2	3	4	5	6	7
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca				

## MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks

- (a) Give **two** differences between column 1 in **Figure 1** and Group 1 in the modern periodic table.

Use the periodic table to help you.

1. \_\_\_\_\_  
\_\_\_\_\_
2. \_\_\_\_\_  
\_\_\_\_\_

(2)

- (b) In 1869 Mendeleev produced his periodic table.

Complete the sentence.

Choose the answer from the box.

<b>insoluble</b>	<b>magnetic</b>	<b>undiscovered</b>	<b>unreactive</b>
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Mendeleev left gaps in his periodic table for elements that were \_\_\_\_\_ .

(1)

- (c) How are the elements ordered in the modern periodic table?

Tick **one** box.

Atomic mass

Atomic number

Melting point

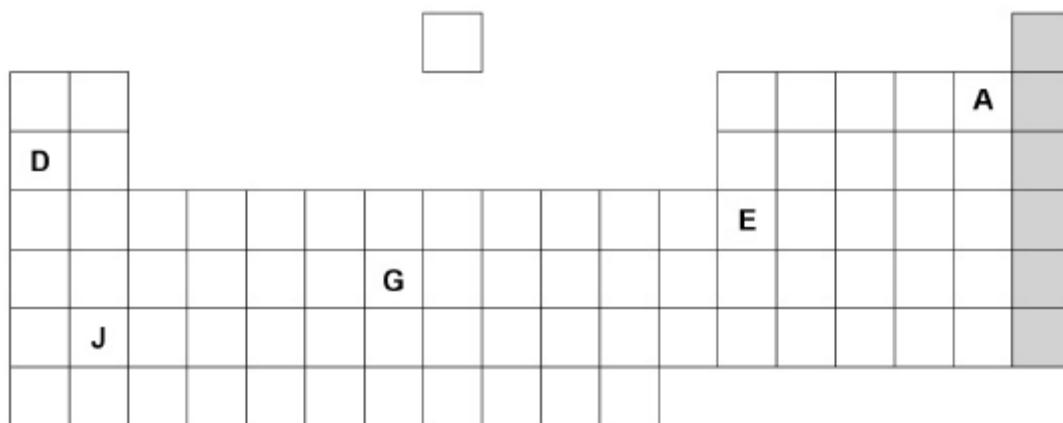
Reactivity

(1)

**MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks**

**Figure 2** shows part of the modern periodic table.

**Figure 2**



- (d) Complete the sentences about the elements in **Figure 2**.

Choose the answers from the box.

A      D      E      G      J

Sodium is an alkali metal and is represented by the letter \_\_\_\_\_.

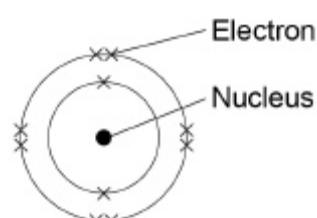
An element in group 3 is represented by the letter \_\_\_\_\_.

A gaseous non-metal element is represented by the letter \_\_\_\_\_.

(3)

- (e) **Figure 3** shows the electronic structure of an atom.

**Figure 3**



This element is in the shaded group on **Figure 2**.

Why is this element unreactive?

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(1)

## MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks

- (f) Name the group of elements in the shaded column on **Figure 2**.

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(1)  
**(Total 9 marks)**

### Q4.

In 1869, Dmitri Mendeleev produced his periodic table of the elements.

Mendeleev placed the alkali metals in the same group.

- (a) What evidence did Mendeleev use to decide that the alkali metals should be in the same group?

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(1)

- (b) Describe how the elements in the modern periodic table are arranged:

- (i) in terms of protons

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(1)

- (ii) in terms of electrons.

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(1)

- (c) State **two** properties of transition elements that make them more useful than alkali metals for making water pipes.

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(2)

- (d) Describe and explain the trend in reactivity of the alkali metals (Group 1).

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**MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks**

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(4)

(Total 9 marks)

Q5.

This question is about elements and the periodic table.

- (a) Use the correct answers from the box to complete the sentences.

atoms	atomic weights	electrons	proton numbers
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Newlands' and Mendeleev's periodic tables show the elements in order of their

Following the discovery of protons and \_\_\_\_\_, the modern periodic table shows the elements in order of their \_\_\_\_\_.

(3)

- (b) **Figure 1** shows the position of six elements in the modern periodic table.

**Figure 1**

- (i) Which **one** of these six elements has the lowest boiling point?

**MYP 5 – E-Assessment revision - Periodic table (trends, periods, groups) – 43 marks**

(1)

- (ii) Complete the sentence.

In the periodic table, rubidium (Rb) is in Group \_\_\_\_\_.

(1)

- (iii) Which of these three elements is the most reactive?

Tick (✓) one box.

Lithium (Li)

Sodium (Na)

Potassium (K)

(1)

- (iv) Which two statements are correct?

Tick (✓) two boxes.

Iron has a higher density than potassium.

Iron is softer than potassium.

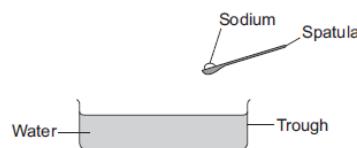
Iron reacts vigorously with water.

Iron forms ions that have different charges.

(2)

- (c) Figure 2 shows sodium being put into water.

Figure 2



Describe three observations that can be seen when sodium is put into water.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

(3)

(Total 11 marks)

Multiple Choice Questions

# Formulae, Functional Groups & Terminology

Organic Formulae / Homologous Series / Saturated & Unsaturated Compounds / Naming Organic Compounds

Easy (5 questions)	/5
Medium (5 questions)	/5
Hard (5 questions)	/5
<b>Total Marks</b>	<b>/15</b>

**Scan here for your answers**  
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# Easy Questions

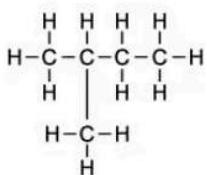
1 Which of the following formulae shows an alkane?



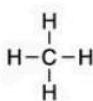
(1 mark)

2 Which of the following structures shows a compound that belongs to a different homologous series to octane?

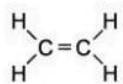
A



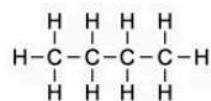
B



C

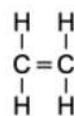


D



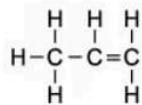
(1 mark)

3 The diagram shows the structure of ethene.

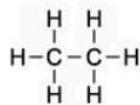


Which of these compounds has similar chemical properties of ethene?

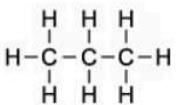
A



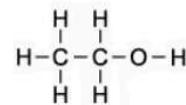
B



C



D

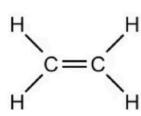


(1 mark)

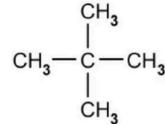
4 The structures of four organic compounds are shown.

Which one does **not** show the displayed formula of the compound?

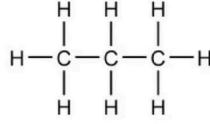
A



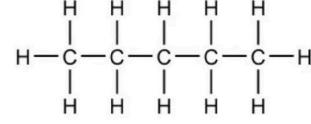
B



C



D



(1 mark)

## 5 Extended Only

Which of the following is **not** a feature of a homologous series?

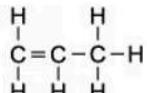
- A.** Compounds have the same functional group
- B.** Compounds have the same physical properties
- C.** Compounds have the same general formula
- D.** Compounds have similar chemical properties

**(1 mark)**

# Medium Questions

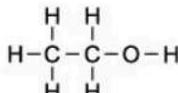
1 Which one of the following structures is correctly named?

A



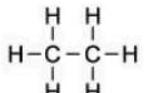
Propane

B



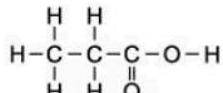
Ethanol

C



Ethene

D



Ethanoic acid

(1 mark)

2 Organic compounds can have names that have the suffixes of -ane, -ene, -ol or -oic acid.

How many of these have at least one double bond in their structure

A. 1

B. 2

C. 3

D. 4

(1 mark)

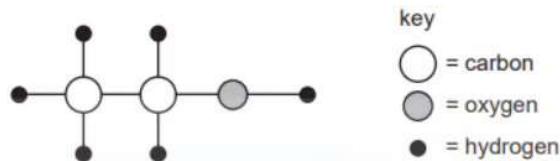
3 When the number of atoms in a molecule of a hydrocarbon increases, the amount of energy released when it burns increases.

What is the correct order?

	<b>less energy</b>	→	<b>more energy released</b>
<b>A</b>	methane	ethene	ethane
<b>B</b>	ethene	ethane	methane
<b>C</b>	ethene	methane	ethane
<b>D</b>	methane	ethane	ethene

**(1 mark)**

- 4** The diagram below represents the molecule of a compound.



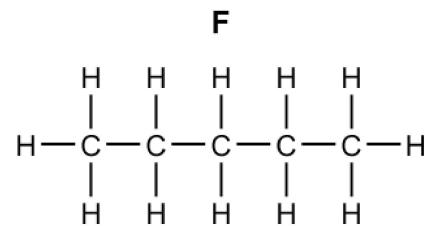
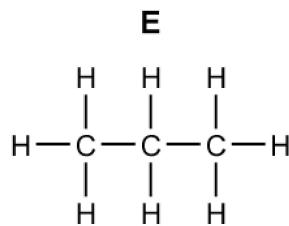
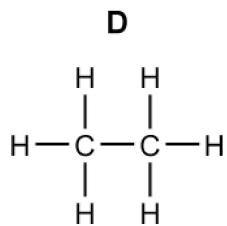
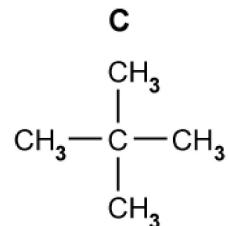
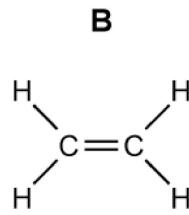
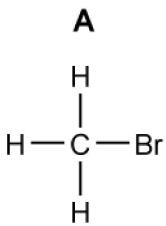
What is the name of this compound?

- A.** Ethane
- B.** Ethanol
- C.** Ethanoic acid
- D.** Ethene

**(1 mark)**

## **5 Separate: Chemistry and Extended Only**

The structures of six organic compounds compound **A** are shown.



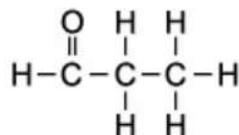
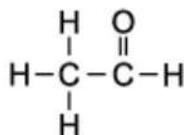
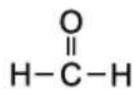
Which two compounds are isomers of one another?

- A.** **B** and **D**
- B.** **A** and **C**
- C.** **C** and **F**
- D.** **C** and **E**

(1 mark)

# Hard Questions

1 The first three members of a homologous series are shown.



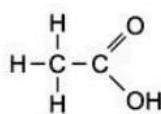
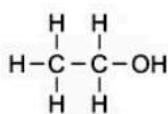
Why do these molecules represent a homologous series?

- A. They contain carbon and hydrogen atoms.
- B. They have saturated bonds.
- C. They have the same functional group.
- D. They react differently from each other.

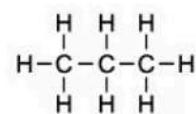
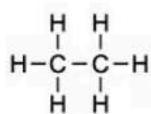
(1 mark)

2 Which pair of the following structures shows a homologous series?

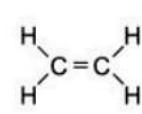
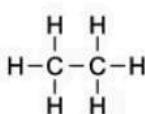
A



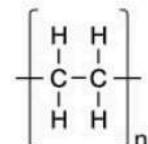
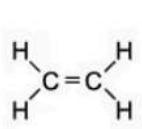
B



C



D



(1 mark)

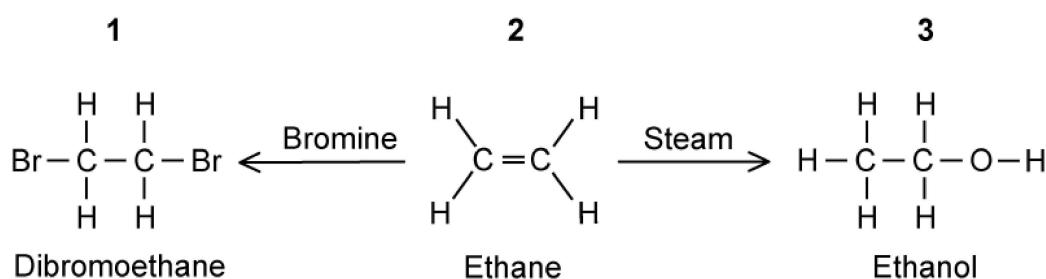
3 Which group of compounds is from a homologous series?

- A. CH<sub>3</sub>OH, C<sub>2</sub>H<sub>5</sub>OH, C<sub>3</sub>H<sub>7</sub>OH
- B. C<sub>3</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>8</sub>, C<sub>3</sub>H<sub>7</sub>OH
- C. CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>3</sub>H<sub>8</sub>
- D. CH<sub>3</sub>CO<sub>2</sub>H, CH<sub>3</sub>CH<sub>2</sub>OH, HCO<sub>2</sub>H

(1 mark)

#### 4 Extended Only

The diagram below shows some simple hydrocarbons and the products of two reactions.



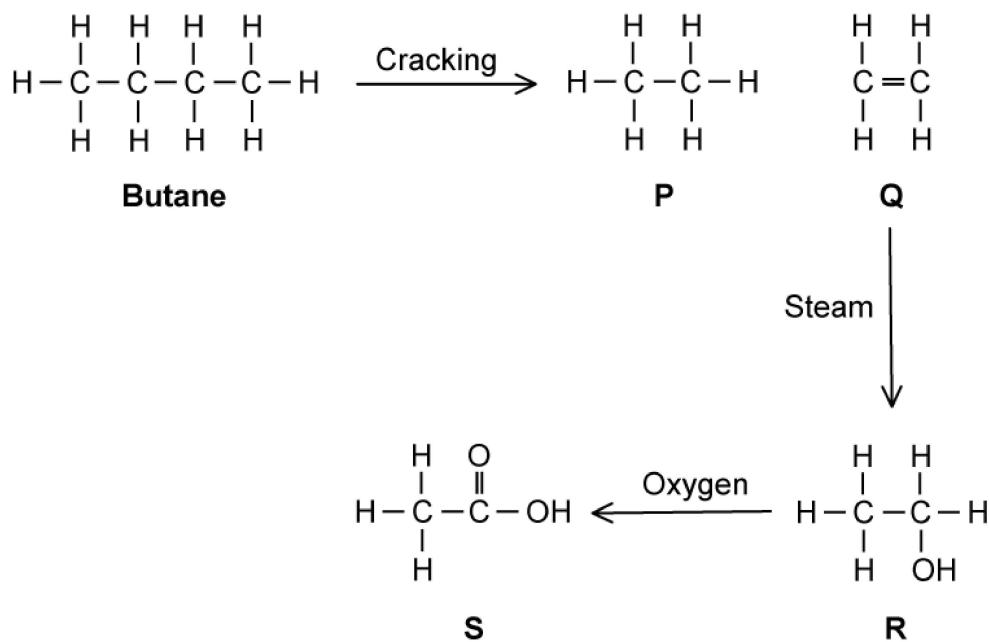
Which of these structures are named correctly?

	Structure 1	Structure 2	Structure 3
A	x	✓	✓
B	✓	✓	✓
C	x	✓	x
D	✓	x	✓

(1 mark)

## 5 Extended Only

The diagram below shows a reaction scheme. What are the names of all of the compounds?



	P	Q	R	S
A	ethene	ethane	ethanoic acid	ethanol
B	ethane	ethene	ethanol	ethanoic acid
C	ethene	ethane	ethanol	ethanoic acid
D	ethane	ethene	ethanoic acid	ethanol

(1 mark)

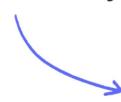
Theory Questions

# Formulae, Functional Groups & Terminology

Organic Formulae / Homologous Series / Saturated & Unsaturated Compounds / Naming Organic Compounds

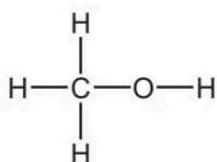
Easy (7 questions)	/13
Medium (13 questions)	/129
Hard (6 questions)	/77
<b>Total Marks</b>	<b>/219</b>

**Scan here for your answers**  
or visit [savemyexams.com](https://www.savemyexams.com)

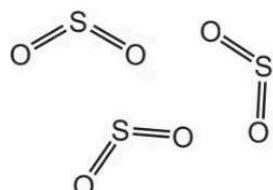


# Easy Questions

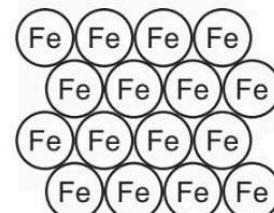
**1** The diagrams show part of the structures of five substances, A, B, C, D and E.



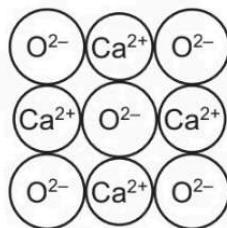
A



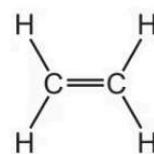
B



c



D

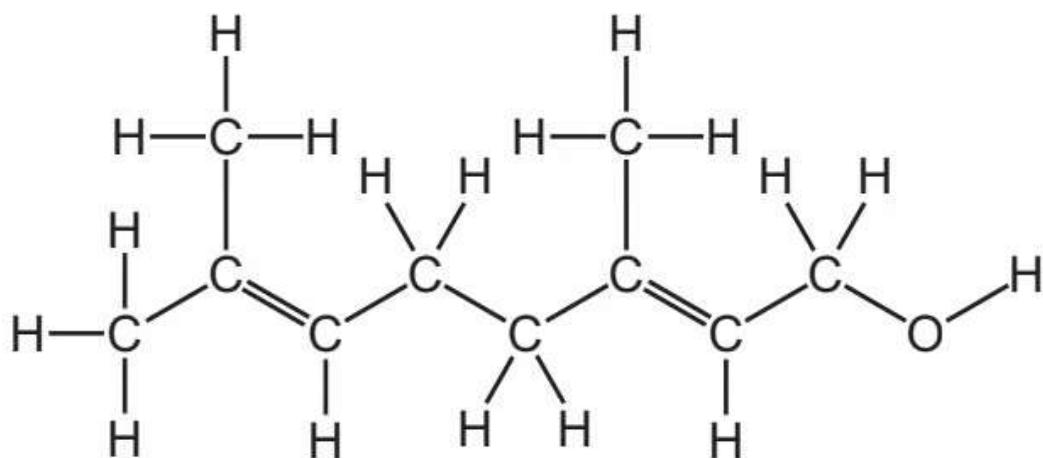


E

Which one of these structures, A, B, C, D or E is an alcohol?

(1 mark)

2 The structure of nerol is shown below:



Draw a circle around the alcohol functional group in nerol.

(1 mark)

**3 (a)** One of the organic acids present in milk is lactic acid.

The displayed formula of lactic acid is shown in Fig. 2.2.

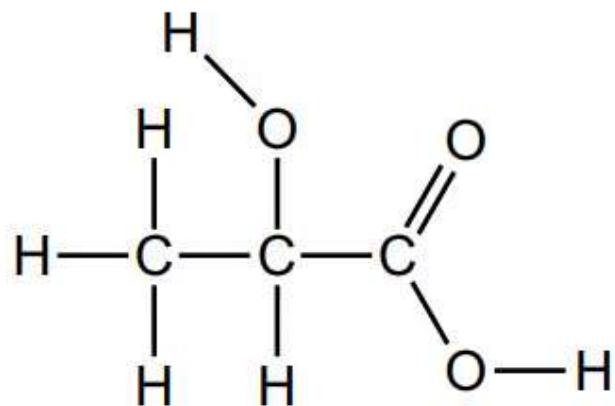


Fig. 2.2

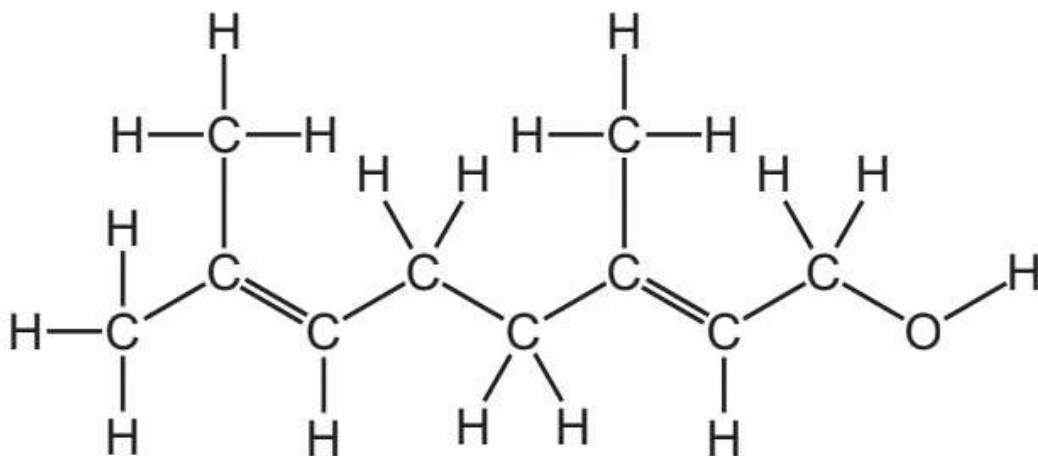
Draw a circle around the carboxylic acid functional group on the structure.

.....  
**(1 mark)**

**(b)** Deduce the molecular formula of lactic acid.

.....  
**(1 mark)**

4 The structure of nerol is shown.



What feature of the nerol molecule shows that it is an unsaturated compound?

---

(1 mark)

5 Sulfur dioxide,  $\text{SO}_2$ , is used in the manufacture of sulfuric acid.

When propan-1-ol is heated with concentrated sulfuric acid as a catalyst an unsaturated hydrocarbon of relative molecular mass 42 is formed and one other product.

What is meant by the term unsaturated?

---

(1 mark)

- 6 (a)** Coal gas is made by heating coal in the absence of air. The list shows the main gases present in coal gas.

**carbon dioxide**  
**carbon monoxide**  
**ethene**  
**hydrogen**  
**methane**  
**nitrogen**

Which one of these gases is an alkane?

---

(1 mark)

- (b)** Draw the structure of a molecule of ethene. Show all of the atoms and all of the bonds.

---

(1 mark)

**7 (a)** Methane, ethane and ethene are hydrocarbons.

Draw the structure of a molecule of ethane. Show all of the atoms and all of the bonds.

---

(1 mark)

**(b)** Which one of these compounds belongs to the same homologous series as methane?

Draw a circle around the correct answer.

**butane**

**methanoic acid**

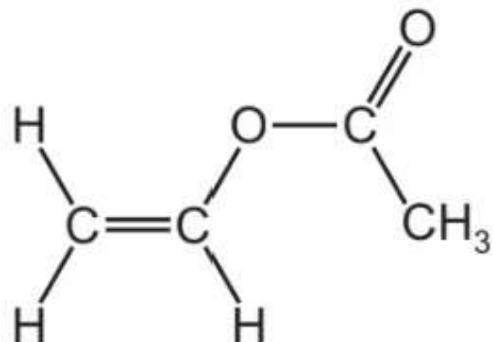
**methanol**

**propene**

---

(1 mark)

**(c)** The structure of a monomer used to make a polymer is shown.



What structural feature of this molecule shows that it is unsaturated?

---

(1 mark)

**(d)** Describe a test to show that this compound is unsaturated. test

..... observations .....

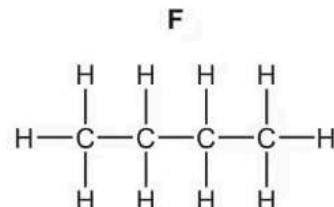
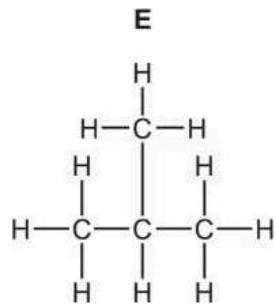
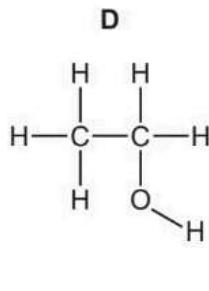
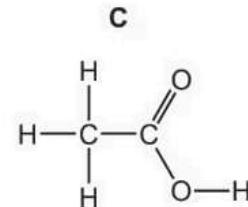
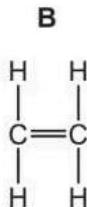
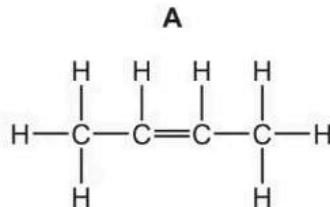
.....

.....

(2 marks)

# Medium Questions

1 (a) The structures of six organic compounds are shown.



Give the name of F.

(1 mark)

(b) Separate: Chemistry Only

Identify **two** of the compounds that are members of the same homologous series.

Give the general formula of this homologous series.

compounds .....

general formula .....

(2 marks)

### (c) Separate: Chemistry and Extended Only

Which **two** compounds are isomers of each other?

Explain why they are isomers.

compounds .....

explanation .....

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**(3 marks)**

(d) Explain why **B** is an unsaturated hydrocarbon.

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**(2 marks)**

### (e) Extended Only

Describe how **D** is manufactured from **B**. Give a chemical equation for the reaction.

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**(3 marks)**

### (f) Extended Only

Compound **A** forms an addition polymer.

Draw **two** repeat units of the addition polymer formed from **A**.

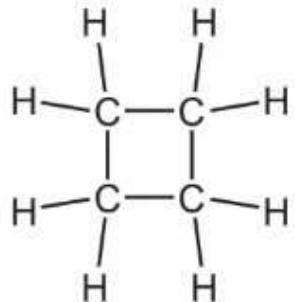
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**(2 marks)**

## 2 (a) Separate: Chemistry and Extended Only

A hydrocarbon has the following structural formula.



i) State the molecular formula and the empirical formula of this hydrocarbon.

molecular formula .....

empirical formula .....

[2]

ii) Draw the structural formula of an isomer of the above hydrocarbon.

[1]

iii) Explain why these two hydrocarbons are isomers.

[2]

iv) Are these two hydrocarbons members of the same homologous series? Give a reason for your choice.

[1]

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**(6 marks)**

**(b)** Alkenes can be made from alkanes by cracking.

i) Explain the term *cracking*.

[2]

ii) One mole of an alkane, when cracked, produced one mole of hexane, C<sub>6</sub>H<sub>14</sub>, and two moles of ethene.

What is the molecular formula of the original alkane?

[1]

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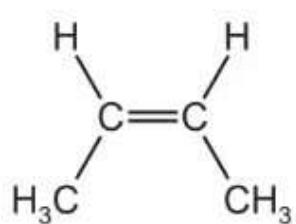
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**(3 marks)**

**(c) Extended Only**

Alkenes are used in polymerisation reactions and addition reactions.

i) Draw the structural formula of the product formed by the addition polymerisation of but-2-ene. Its formula is given below.



[3]

- ii) Give the name and structural formula of the addition product formed from ethene and bromine.

name .....

structural formula .....

[2]

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**(5 marks)**

### 3 (a) Extended Only

The alcohols form a homologous series. The first five members are given in the table below.

alcohol	formula	heat of combustion in kJ / mol
methanol	CH <sub>3</sub> OH	730
ethanol	CH <sub>3</sub> -CH <sub>2</sub> -OH	1380
propan-1-ol		
butan-1-ol	CH <sub>3</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -OH	2680
pentan-1-ol	CH <sub>3</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -OH	3350

i) Complete the table.

[2]

ii) Complete the equation for the combustion of pentan-1-ol in excess oxygen.



[1]

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(3 marks)

**(b) Extended Only**

State **three** characteristics of a homologous series other than the variation of physical properties down the series.

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(3 marks)

**(c) Separate: Chemistry and Extended Only**

The following alcohols are isomers.



i) Explain why they are isomers.

[2]

ii) Draw the structural formula of another isomer of the above alcohols.

[1]

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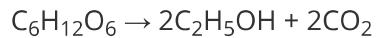
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(3 marks)

**(d) Extended Only**

Alcohols can be made by fermentation and from petroleum.

- i) Ethanol is made from sugars by fermentation.



The mass of one mole of glucose,  $C_6H_{12}O_6$ , is 180 g.

Calculate the maximum mass of ethanol which could be obtained from 72 g of glucose.

[3]

- ii) Describe how ethanol is made from petroleum.

**petroleum (alkanes) → ethene → ethanol**

[3]

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(6 marks)

#### 4 (a) Extended Only

The alcohols form a homologous series.

Give **three** characteristics of a homologous series.

.....  
.....  
.....

(3 marks)

#### (b) Separate: Chemistry and Extended Only

The following two alcohols are members of an homologous series and they are isomers.



i) Explain why they are isomers.

[2]

ii) Deduce the structural formula of another alcohol which is also an isomer of these alcohols.

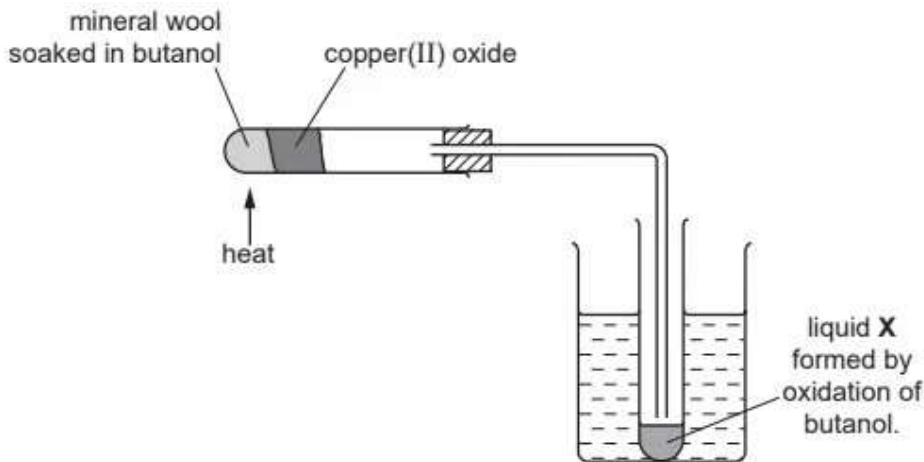
[1]

.....  
.....  
.....

(3 marks)

#### (c) Separate: Chemistry and Extended Only

Copper(II) oxide can oxidise butanol to liquid X, whose pH is 4.



i) Give the name of another reagent which can oxidise butanol.

[1]

ii) Which homologous series does liquid X belong to?

[1]

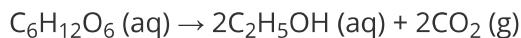
iii) State the formula of liquid X.

[1]

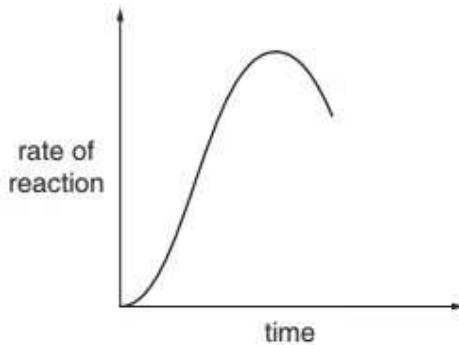
.....  
.....  
.....  
  
(3 marks)

#### (d) Separate: Chemistry and Extended Only

The alcohol ethanol can be made by fermentation. Yeast is added to aqueous glucose.



Carbon dioxide is given off and the mixture becomes warm, as the reaction is exothermic. The graph shows how the rate of reaction varies over several days.



i) Suggest a method of measuring the rate of this reaction.

[2]

ii) Why does the rate initially increase?

[1]

iii) Suggest **two** reasons why the rate eventually decreases.

[2]

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**(5 marks)**

## 5 (a) Extended Only

Methanoic acid is the first member of the homologous series of carboxylic acids.

Give **two** general characteristics of a homologous series.

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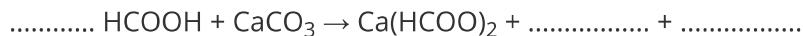
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(2 marks)

## (b) Extended Only

In some areas when water is boiled, the inside of kettles become coated with a layer of calcium carbonate. This can be removed by adding methanoic acid.

i) Complete the equation.



[2]

ii) Methanoic acid reacts with most metals above hydrogen in the reactivity series.

Complete the word equation.



[2]

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(4 marks)

### (c) Separate: Chemistry and Extended Only

Give the name, molecular formula and empirical formula of the fourth acid in this series.

name .....

[1]

molecular formula .....

[1]

empirical formula .....

[1]

.....  
.....  
.....  
**(3 marks)**

## 6 (a) Extended Only

Two homologous series of hydrocarbons are the alkanes and the alkenes.

One general characteristic of a homologous series is that the physical properties vary in a predictable way.

i) State **three** other general characteristics of a homologous series.

[3]

ii) How can the molecular formula of a hydrocarbon show whether it is an alkane or an alkene?

[2]

iii) How do alkanes and alkenes differ in their molecular structures?

[2]

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(7 marks)

**(b)** Cracking is the thermal decomposition of alkanes into smaller hydrocarbons and possibly hydrogen.

i) State **two** conditions required for the cracking of an alkane.

[2]

ii) One type of cracking produces an alkane and an alkene.

Complete an equation for the cracking of heptane into an alkane and an alkene.



[1]

iii) Complete an equation for the cracking of heptane into hydrogen and two other products.



[1]

iv) Suggest **one** reason why cracking is important.

[1]

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**(5 marks)**

**7 (a)** Petrol is a mixture of hydrocarbons and additives. The combustion of petrol in car engines is a major source of air pollution. This is reduced by catalytic converters.

Petrol is obtained from the gasoline fraction, boiling point range 40 °C to 100 °C, from the distillation of petroleum.

Explain the term *fraction*.

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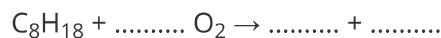
(2 marks)

### **(b) Extended Only**

In many countries, a lead compound of the type  $\text{Pb}(\text{C}_2\text{H}_5)_n$  used to be added to petrol to improve its combustion. After combustion, lead oxide was formed.



i) Octane is a constituent of petrol. Write the equation for the complete combustion of octane.



[2]

ii) Dibromoethane was added to petrol to remove the lead oxide from inside the engine. Lead bromide was formed which escaped into the environment through the exhaust. Leaded petrol cannot be used with a catalytic converter.

Give another reason why leaded petrol is no longer used.

[1]

iii) What does each of the following tell you about the structure of dibromoethane?

dibromo .....

eth .....

ane .....

[2]

iv) What additional information is needed to draw the structural formula of dibromoethane?

[1]

.....  
.....  
.....  
.....  
.....  
.....

**(6 marks)**

### (c) Extended Only

An analysis of the compound,  $\text{Pb}(\text{C}_2\text{H}_5)_n$ , showed that 0.026 moles of Pb was combined with 0.104 moles of  $\text{C}_2\text{H}_5$  groups.

What is the value of n? Show how you arrived at your answer.

---

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(2 marks)

### (d) Extended Only

Some of the pollutants emitted by vehicle exhausts are carbon monoxide, oxides of nitrogen and unburnt hydrocarbons. Explain how the emission of these gases is reduced by a catalytic converter.

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(3 marks)

## 8 (a) Extended Only

Methanoic acid is the first member of the homologous series of carboxylic acids.

Give **two** general characteristics of a homologous series.

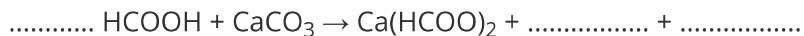
.....  
.....

(2 marks)

## (b) Extended Only

In some areas when water is boiled, the inside of kettles become coated with a layer of calcium carbonate. This can be removed by adding methanoic acid.

i) Complete the equation.



[2]

ii) Methanoic acid reacts with most metals above hydrogen in the reactivity series.  
Complete the word equation.



[2]

iii) Aluminium is also above hydrogen in the reactivity series.

Why does methanoic acid not react with an aluminium kettle?

[1]

.....  
.....  
.....  
.....

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**(5 marks)**

### **(c) Separate: Chemistry and Extended Only**

Give the name, molecular formula and empirical formula of the fourth acid in this series.

name .....

[1]

molecular formula .....

[1]

empirical formula .....

[1]

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**(3 marks)**

- 9 (a)** Alkynes and alkenes are homologous series of unsaturated hydrocarbons. All alkynes contain a C≡C triple bond.

Complete Table 10.1 showing information about the first **three** alkynes.

**Table 10.1**

formula	$C_2H_2$	$C_3H_4$	
structure		$H - C \equiv C - CH_3$	$H - C \equiv C - CH_2 - CH_3$
names	ethyne		but-1-yne

.....  
.....  
**(2 marks)**

### **(b) Extended Only**

Compounds in the same homologous series have the same general formula.

Give two **other** characteristics of members of a homologous series.

.....  
.....  
**(2 marks)**

### **(c) Separate: Chemistry Only**

Deduce the general formula of alkynes. Use the information from Table 10.1 to help you.

.....  
**(1 mark)**

**(d) Alkynes are unsaturated.**

Describe a test for unsaturation.

test .....

result .....

.....  
.....  
**(2 marks)**

### **(e) Separate: Chemistry and Extended Only**

Ethene and but-2-ene are alkenes. Draw the displayed formula of but-2-ene.

.....  
.....  
**(2 marks)**

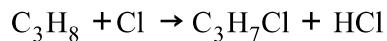
### **(f) Extended Only**

Draw a dot-and-cross diagram to show a molecule of ethene,  $\text{CH}_2=\text{CH}_2$ . Show outer shell electrons only.

.....  
.....  
**(2 marks)**

## 10 (a) Separate: Chemistry and Extended Only

Propane reacts with chlorine in a photochemical reaction as shown.



Draw two structural isomers of compounds with the formula  $\text{C}_3\text{H}_7\text{Cl}$ .

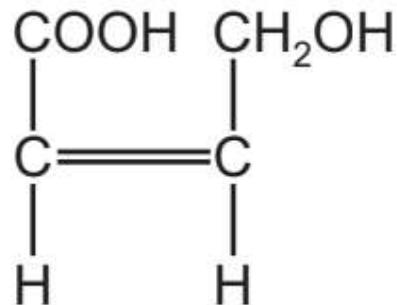
Show all of the atoms and all of the bonds.

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(2 marks)

(b) There are three functional groups in compound A.

compound A



Name the homologous series of compounds that contains the following structures.

C=C .....

-OH .....

-COOH .....

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**(3 marks)**

**(c) Extended Only**

Compound A can be used as a single monomer to produce two different polymers.

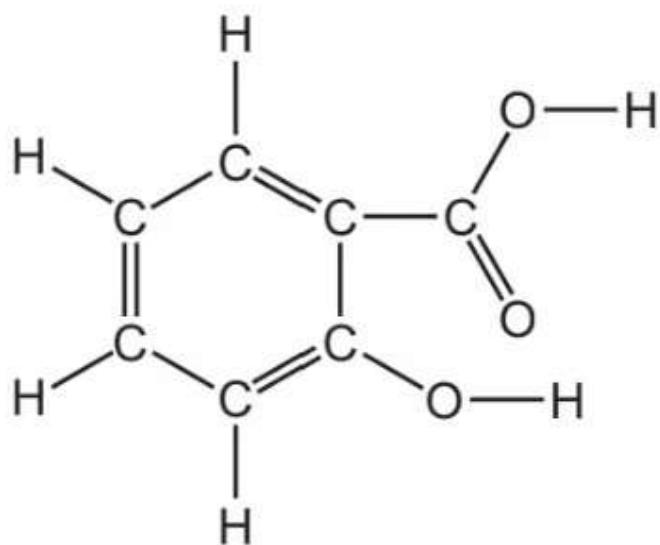
Draw one repeat unit of the addition polymer formed from compound A.

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**(2 marks)**

**11 (a)** The structure of compound S is shown.



Draw a circle around the carboxylic acid functional group in this structure.

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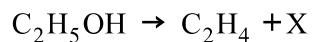
(1 mark)

**(b)** How many different **types** of atom are shown in this structure?

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(1 mark)

**(c)** Ethanol can be converted into ethene by passing ethanol vapour over a catalyst of aluminium oxide.

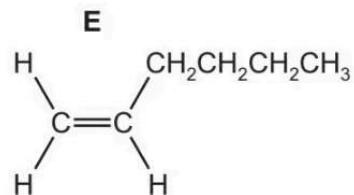
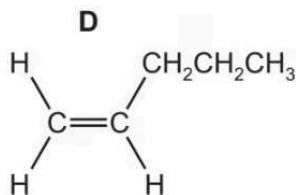
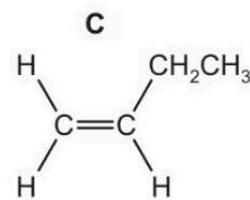
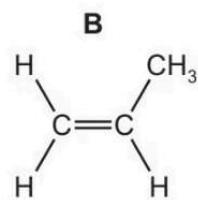
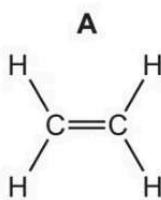


Draw the structure of a molecule of ethanol. Show all of the atoms and all of the bonds.

---

(1 mark)

**12 (a)** The structures of five alkenes, A, B, C, D and E, are shown.



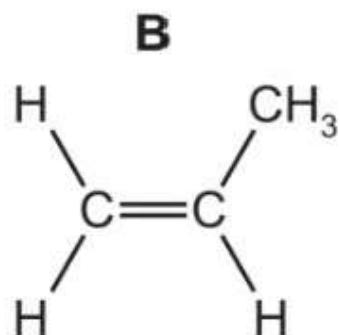
What is the general formula of alkenes?

---

(1 mark)

### (b) Extended Only

Two different alcohols can be produced from alkene **B** by an addition reaction.



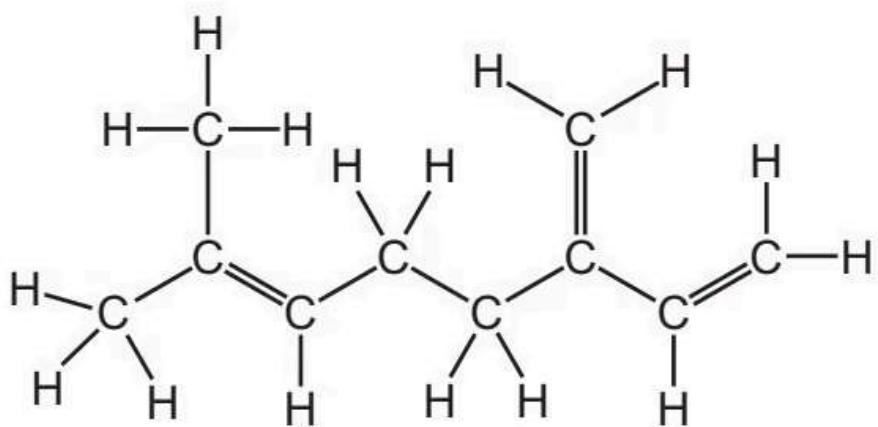
Draw the structures of the **two** alcohols. Show all of the atoms and all of the bonds.

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(2 marks)

**13 (a)** The structure of myrcene is shown.



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

(1 mark)

**(b)** 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 marks)

**(c)** 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 mark)

# Hard Questions

**1 (a)** Alkanes and alkenes are examples of hydrocarbons.

i) What is meant by the term hydrocarbon?

[1]

ii) Give the general formula of straight-chain

alkanes.

alkenes.

[2]

---

---

---

**(3 marks)**

**(b)** A compound X contains carbon, hydrogen and oxygen only.

X contains 54.54% of carbon by mass, 9.09% of hydrogen by mass and 36.37% of oxygen by mass.

i) Calculate the empirical formula of compound X.

[2]

ii) Compound X has a relative molecular mass of 88.

Deduce the molecular formula of compound X.

[2]

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**(4 marks)**

**(c) Extended Only**

An ester has the molecular formula  $C_3H_6O_2$ .

Name and give the structural formulae of two esters with the molecular formula  $C_3H_6O_2$ .

<b>Name of ester</b>		
<b>Structural formula</b>		

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**(4 marks)**

**(d) Separate: Chemistry and Extended Only**

Name the ester produced from the reaction of propanoic acid and methanol.

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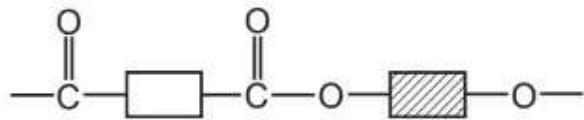
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**(1 mark)**

**(e) Separate: Chemistry and Extended Only**

A polyester is represented by the structure shown.



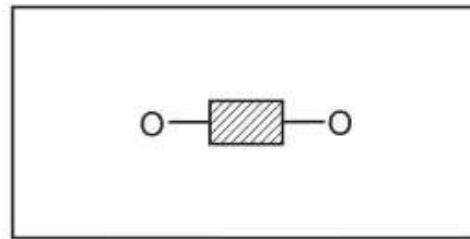
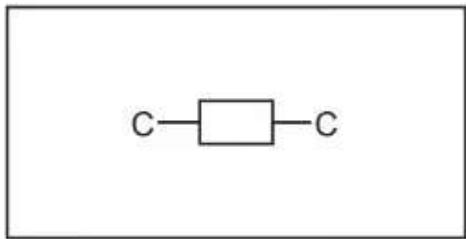
i) What type of polymerisation is used for the production of polyesters?

[1]

ii) Which simple molecule is removed when the polyester is formed?

[1]

iii) Complete the diagrams below to show the structures of the monomers used to produce the polyester. Show all atoms and bonds.



[2]

(4 marks)

**2 (a)** Propanoic acid is a carboxylic acid. Its formula is CH<sub>3</sub>–CH<sub>2</sub>–COOH.

Propanoic acid is the third member of the homologous series of carboxylic acids.

- i) Give the name and structural formula of the fourth member of this series.

name .....

formula .....

[2]

- ii) Members of a homologous series have very similar chemical properties.

State **three** other characteristics of a homologous series.

[3]

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**(5 marks)**

**(b)** Carboxylic acids can be made by the oxidation of alcohols.

- i) Draw the structural formula of the alcohol which can be oxidised to propanoic acid.  
Show all atoms and bonds.

[1]

- ii) Name a reagent, other than oxygen, which can oxidise alcohols to carboxylic acids.

[2]

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---

**(3 marks)**

**(c)** Complete the following equations for some of the reactions of propanoic acid.

The salts of this acid are called propanoates.



[1]



[1]



[1]

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**(3 marks)**

- (d) A piece of magnesium was added to 100 cm<sup>3</sup> of an aqueous acid. The time taken for the metal to react completely was measured. This experiment was repeated using different aqueous acids. The same volume of acid was used in each experiment and the pieces of magnesium used were identical. In one experiment the reaction was carried out at a different temperature.

experiment	acid	concentration in mol / dm <sup>3</sup>	temperature / °C	time / minutes
A	propanoic	1.0	20	5
B	propanoic	1.0	30	3
C	propanoic	0.5	20	8
D	hydrochloric	1.0	20	1

Explain the following in terms of collision rate between reacting particles.

i) Why is the rate in experiment **C** slower than the rate in experiment **A**?

[2]

ii) Why is the rate in experiment **B** faster than the rate in experiment **A**?

[2]

iii) Why is the rate in experiment **D** faster than the rate in experiment **A**?

[3]

.....  
.....  
.....  
.....  
.....  
.....  
.....  
**(7 marks)**

- 3 (a)** The alcohols form a homologous series. The first member is methanol and the fourth is butanol.

$\text{CH}_3\text{-OH}$ methanol	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-OH}$ butanol
-------------------------------------	---

i) Give **two** general characteristics of a homologous series.

[2]

ii) Calculate the mass of one mole of the C<sub>8</sub> alcohol.

[2]

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**(4 marks)**

**(b)** Give the name and structural formula of the third member of this series.

name .....

[1]

structural formula .....

[1]

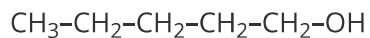
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**(2 marks)**

(c) The structural formula of the fifth member, pentan-1-ol, is drawn below.



i) Draw the structural formula of an isomer of this alcohol.

[1]

ii) Predict the names of the product(s) formed when pentan-1-ol

- reacts with an excess of oxygen,

..... and .....

[1]

- is dehydrated to form an alkene,

.....

[1]

- is oxidised by acidified potassium dichromate(VI).

.....

[1]

.....  
.....  
.....  
.....

**(4 marks)**

**4 (a)** Butane is oxidised to a mixture of carboxylic acids by oxygen in the presence of a catalyst. The acids formed are methanoic acid, ethanoic acid and propanoic acid – the first three members of the carboxylic acid homologous series.

i) Give the name and structural formula of the fourth member of this series.

name .....

structural formula showing all the atoms and bonds

[3]

ii) State **three** characteristics of a homologous series.

[3]

iii) All members of this series are weak acids.

What is meant by the term *weak acid*?

[3]

(9 marks)

**(b)** Carboxylic acids react with alcohols to form esters. Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate,  $\text{CH}_3\text{COOCH}_2\text{CH}_3$ .

i) Give the name and formula of the ester which is formed from methanol and propanoic acid.

name .....

formula .....

[2]

ii) What is the name of the ester which has the formula  $\text{CH}_3\text{COOCH}_3$ ?

[1]

---

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**(3 marks)**

**(c)** i) Complete the equation for the oxidation of butane to propanoic acid.



[1]

ii) Name another compound which can be oxidised to propanoic acid.

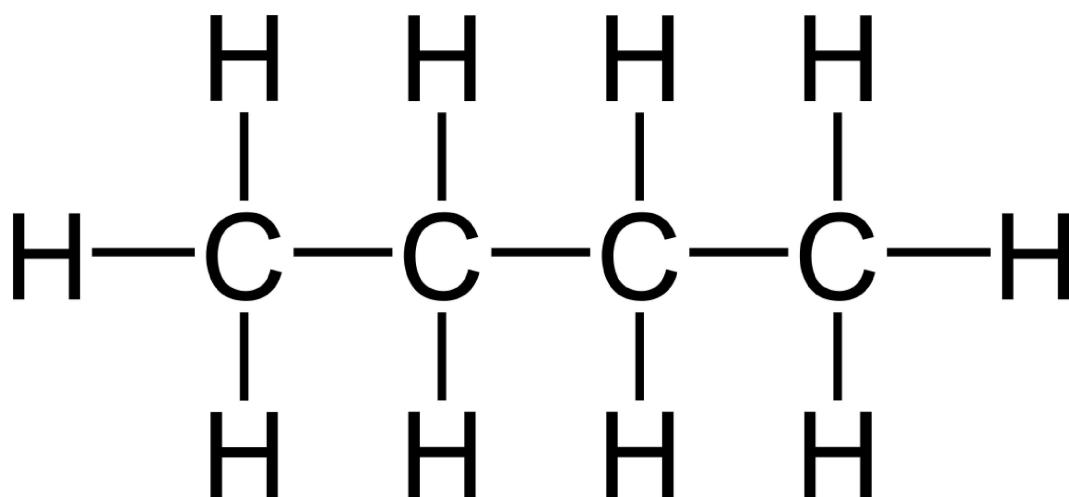
[1]

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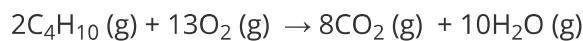
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**(2 marks)**

**5 (a)** Butane is an alkane. It has the following structural formula



The equation for the complete combustion of butane is given below. Insert the two missing volumes.



volume of gas / cm<sup>3</sup> ..... 40

---

(2 marks)

**(b)** Butane reacts with chlorine to form two isomers of chlorobutane.

i) What type of reaction is this?

[1]

ii) Explain the term *isomer*.

[2]

iii) Draw the structural formulae of these two chlorobutanes.

[2]

.....  
.....  
.....  
.....  
.....  
**(5 marks)**

- (c)** One of the chlorobutanes reacts with sodium hydroxide to form butan-1-ol. Butan-1-ol can be oxidised to a carboxylic acid.

i) State a reagent, other than oxygen, which will oxidise butan-1-ol to a carboxylic acid.

[1]

ii) Name the carboxylic acid formed.

[1]

iii) Butan-1-ol reacts with ethanoic acid to form an ester. Name this ester and give its structural formula showing all the individual bonds.

name .....

[1]

structural formula

[2]

.....  
.....  
.....  
.....  
.....  
.....  
.....

**(5 marks)**

**6 (a)** The table shows some information about aldehydes.

Complete the table.

name	.....	ethanal	propanal	butanal
molecular formula	CH <sub>2</sub> O	C <sub>2</sub> H <sub>4</sub> O	C <sub>3</sub> H <sub>6</sub> O	.....

.....

.....

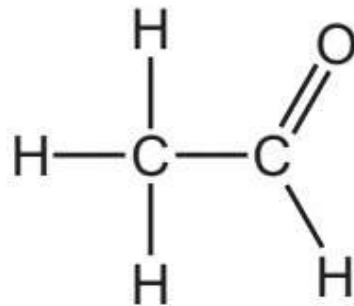
**(2 marks)**

**(b)** Deduce the general formula of aldehydes.

.....

**(1 mark)**

**(c)** The structural formula of ethanal is shown.



The C=O group in aldehydes is at the end of the carbon chain. This is a reactive part of the molecule.

What is the name given to the reactive part of any organic molecule?

.....

**(1 mark)**

- (d) Propanone belongs to a homologous series called ketones. Ketones have the same C=O group as aldehydes but the C=O group is not at the end of the carbon chain. Propanone has the same molecular formula as propanal, C<sub>3</sub>H<sub>6</sub>O.

What term is used to describe molecules with different structures but with the same molecular formula?

---

(1 mark)

- (e) Suggest the structure of propanone, C<sub>3</sub>H<sub>6</sub>O. Show all of the atoms and all of the bonds.

---

(2 marks)

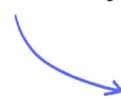
Paper 1 &amp; Paper 2

# Introduction

Organic Compounds / Naming Organic Compounds / Classifying Organic Reactions

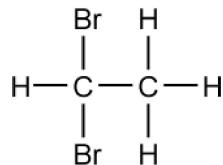
Easy (5 questions)	/22
Medium (5 questions)	/33
Hard (5 questions)	/52
<b>Total Marks</b>	<b>/107</b>

**Scan here for your answers**  
or visit [savemyexams.com](https://www.savemyexams.com)



# Easy Questions

1 The displayed formulae of an organic compound is shown below.



What is the empirical formula of this compound?

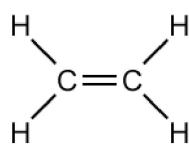
- A CHBr
- B CH<sub>2</sub>Br
- C C<sub>2</sub>H<sub>4</sub>Br<sub>2</sub>
- D CH<sub>4</sub>Br

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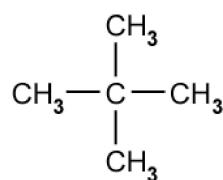
(1 mark)

2 The structures of four organic compounds are shown.

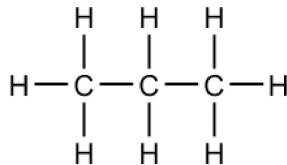
A



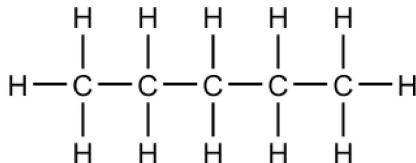
B



C



D



Which one does **not** show the displayed formula of the compound?

- A**
  - B**
  - C**
  - D**
- 

**(1 mark)**

**3** Which of the following is **not** a feature of a homologous series?

- A** Compounds have the same functional group
  - B** Compounds have the same physical properties
  - C** Compounds have the same general formula
  - D** Compounds have similar chemical properties
- 

**(1 mark)**

**4 (a)** This question is about alkanes and alkenes.

Complete the boxes by giving the missing information about the alkene with the molecular formula C<sub>2</sub>H<sub>4</sub>.

<b>Molecular formula</b>	C <sub>2</sub> H <sub>4</sub>
<b>Name</b>	
<b>Empirical formula</b>	
<b>General formula</b>	
<b>Displayed formula</b>	

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**(4 marks)**

**(b)** Alkenes are unsaturated hydrocarbons.

State what is meant by the terms **unsaturated** and **hydrocarbon**.

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**(3 marks)**

**(c)** Butene, C<sub>4</sub>H<sub>8</sub>, is a member of the same homologous series as C<sub>2</sub>H<sub>4</sub>.

Use the words in the box to complete the sentences.

chemical	general	group	functional
molecular	period	physical	structural

Butene, C<sub>4</sub>H<sub>8</sub>, and C<sub>2</sub>H<sub>4</sub> have the same ..... formula and ..... group.

They will show similar ..... properties but there will be differences in their ..... properties, such as density and boiling point.

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**(4 marks)**

**(d)** When the alkene butene reacts with bromine, the product is dibromobutane, C<sub>4</sub>H<sub>8</sub>Br<sub>2</sub>.

i) Give a word equation for this reaction.

(1)

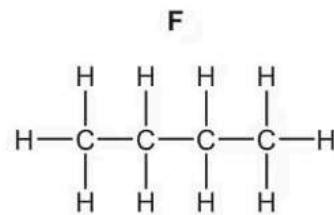
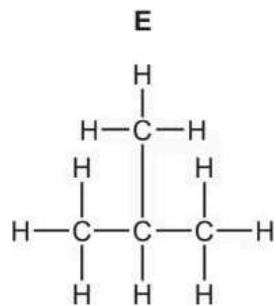
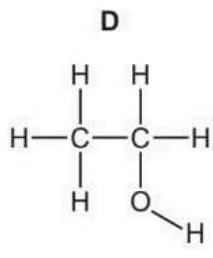
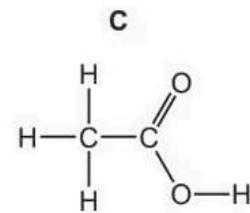
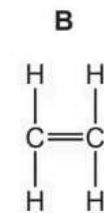
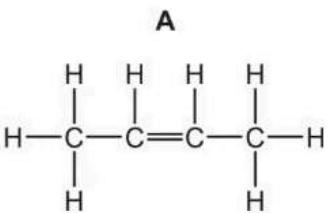
ii) What is the name of this type of reaction?

(1)

- A** addition
  - B** decomposition
  - C** neutralisation
  - D** substitution
- 
- 

**(2 marks)**

**5 (a)** The structures of six organic compounds are shown.



Give the name of **F**.

(1 mark)

**(b)** Identify two compounds that are members of the same homologous series.

(1 mark)

**(c)** Compounds **E** and **F** are isomers of each other.

State what is meant by the term **isomers**.

(2 marks)

**(d)** Explain why **B** is an unsaturated hydrocarbon.

---

(2 marks)

# Medium Questions

**1 (a)** Ethene ( $C_2H_4$ ) can be converted into chloroethene ( $C_2H_3Cl$ ) in a two-stage process.

The first stage is to convert ethene into 1,2-dichloroethane,  $C_2H_4Cl_2$

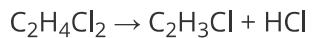
Ethene is reacted with hydrogen chloride and oxygen.

Complete the chemical equation for this reaction.



(1 mark)

**(b)** In the second stage, 1,2-dichloroethane is converted into chloroethene.

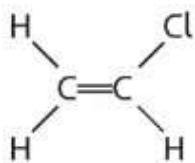


This is a thermal decomposition reaction.

State what is meant by the term **thermal decomposition**.

(1 mark)

**(c)** The diagram shows the displayed formula of chloroethene.



i) State why chloroethene is described as an unsaturated compound.

(1)

- ii) Describe a test to show that chloroethene is unsaturated.

(2)

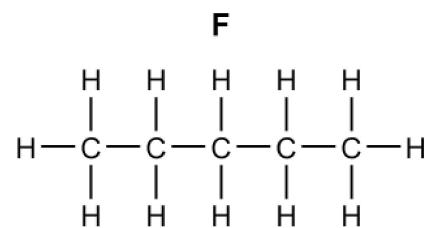
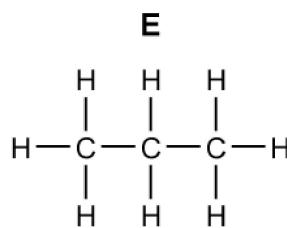
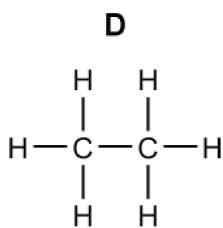
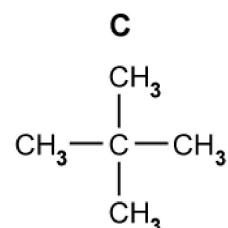
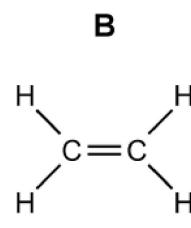
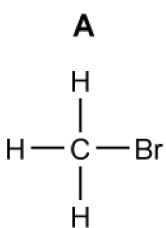
.....  
.....  
.....

(3 marks)

- (d) Name the polymer formed from chloroethene.

.....  
(1 mark)

- 2 The structures of six organic compounds are shown.



Which two compounds are isomers of one another?

- A** B and D
- B** A and C
- C** C and F
- D** C and E

---

(1 mark)

3 Which of the following reactions is an example of an addition reaction?

- A**  $\text{CH}_4 + \frac{1}{2}\text{O}_2 \rightarrow \text{CO} + 2\text{H}_2\text{O}$
- B**  $\text{C}_2\text{H}_4 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2$
- C**  $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- D**  $\text{CH}_4 + \text{Br}_2 \rightarrow \text{CH}_3\text{Br} + \text{HBr}$

---

(1 mark)

**4 (a)** This question is about organic compounds.

Propane is the third member of the homologous series of alkanes.

- i) State the name of the third member of the homologous series of alkenes.

(1)

- ii) Explain why propane and the third member of the homologous series of alkenes do not have similar chemical properties.

(1)

---

---

**(2 marks)**

**(b)** Propene is bubbled through bromine water until there is no further colour change.

- i) Give the chemical equation for this reaction.

(1)

- ii) How does the observation support that this is an addition reaction?

(2)

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---

**(3 marks)**

### (c) Separate: Chemistry Only

In industry, ethene is reacted with steam to form ethanol.

- i) Using structural formulae, give the chemical equation for this reaction.

(1)

- ii) State the temperature and pressure required for this reaction.

(2)

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(3 marks)

### (d) Separate: Chemistry Only

Ethanol oxidises slowly in air to form a chemical that is a member of a different homologous series and has a bitter smell.

- i) State the homologous series to which the oxidation product belongs.

(1)

- ii) Give the empirical and molecular formulae of the oxidation product.

(2)

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**(3 marks)**

**5 (a)** The alcohols form a homologous series with the general formula  $C_nH_{2n+1}OH$ .

The first five members of the homologous series are given in the table below.

alcohol	formula
<b>methanol</b>	$CH_3OH$
<b>ethanol</b>	$CH_3-CH_2-OH$
<b>propan-1-ol</b>	
<b>butan-1-ol</b>	$CH_3-CH_2-CH_2-CH_2-OH$
<b>pentan-1-ol</b>	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$

i) Complete the table.

(1)

ii) Complete the equation for the reaction of butan-1-ol in excess oxygen.



(2)

iii) What is the name of the type of reaction occurring between butan-1-ol and oxygen?

(1)

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**(4 marks)**

**(b)** State **three** characteristics of a homologous series other than the variation of physical properties down the series.

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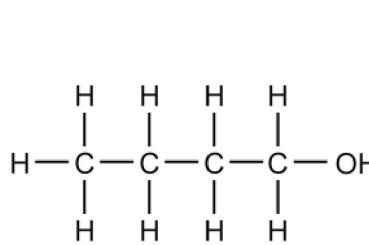
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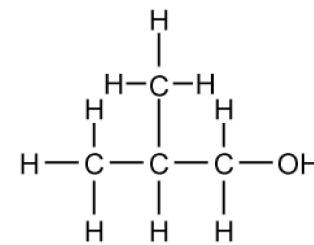
**(3 marks)**

**(c)** There are four isomers with the molecular formula C<sub>4</sub>H<sub>9</sub>OH that are alcohols.

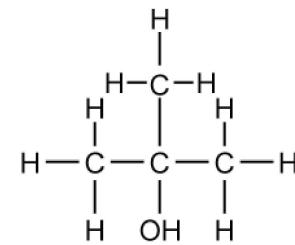
These are the displayed formulae of the isomers.



**Butan-1-ol**



**2-Methylpropan-1-ol**



**2-Methylpropan-2-ol**

i) Explain why they are isomers.

(2)

ii) Draw the displayed formula of the fourth isomer.

(1)

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**(3 marks)**

**(d)** An alcohol has this percentage composition by mass.

$$C = 60.0\% \quad H = 13.3\% \quad O = 26.7\%$$

i) Show by calculation that the molecular formula of the alcohol could be  $C_3H_8O$ .  
(3)

ii) Explain why the empirical formula is also the molecular formula of the alcohol.  
(1)

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**(4 marks)**

# Hard Questions

- 1 (a)** The formulas for four organic compounds are given in the table below.

Write the names of each of the compounds.

Structure	Name
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	
$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$	
$\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3$	
$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	

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**(4 marks)**

- (b)**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$  undergoes a combustion reaction in excess oxygen. Write a balanced symbol equation for this reaction.

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**(2 marks)**

- (c)** Compound A has an  $M_r$  of 102 and contains the same functional group as  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ . Calculate the percentage by mass of carbon in compound A.

( $A_r$ : O = 16, C = 12, H = 1)

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**(2 marks)**

(d) Draw the displayed formula of  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$

.....  
**(1 mark)**

- 2 (a)** Compound X is a hydrocarbon with an  $M_r$  of 70 that contains 85.7% by mass of carbon. When bromine water is added to compound X it remains orange.

Calculate the empirical formula of compound X

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**(3 marks)**

Using the information in part a), determine the structure of compound X.

**(b)**

**(1 mark)**

- (c)** Compound X reacts with chlorine in the presence of ultra-violet light. Write the equation for this reaction.

---

**(1 mark)**

**3 (a)** Alkanes and alkenes are examples of hydrocarbons.

i) What is meant by the term hydrocarbon?

(1)

ii) Give the general formula of straight-chain

alkanes.

alkenes.

(2)

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**(3 marks)**

**(b)** A compound X contains carbon, hydrogen and oxygen only.

X contains 54.54% of carbon by mass, 9.09% of hydrogen by mass and 36.37% of oxygen by mass.

i) Calculate the empirical formula of compound X.

(2)

ii) Compound X has a relative molecular mass of 88.

Deduce the molecular formula of compound X.

(2)

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**(4 marks)**

### (c) Separate: Chemistry Only

An ester has the molecular formula C<sub>3</sub>H<sub>6</sub>O<sub>2</sub>.

Name and give the structural formulae of two esters with the molecular formula C<sub>3</sub>H<sub>6</sub>O<sub>2</sub>.

Name of ester		
Structural formula		

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(4 marks)

### (d) Separate: Chemistry Only

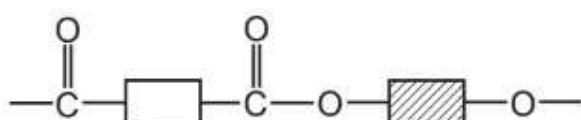
Name the ester produced from the reaction of propanoic acid and methanol.

---

(1 mark)

### (e) Separate: Chemistry Only

A polyester is represented by the structure shown.



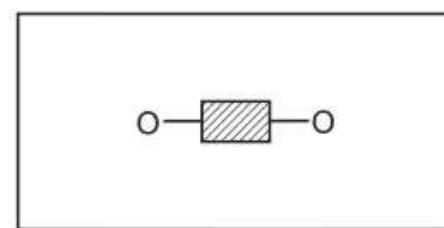
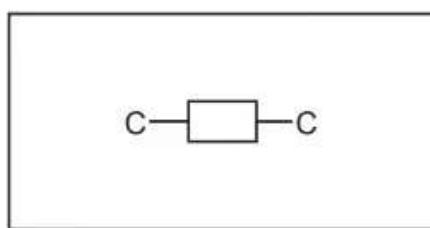
- i) What type of polymerisation is used for the production of polyesters?

(1)

- ii) Which simple molecule is removed when the polyester is formed?

(1)

- iii) Complete the diagrams below to show the structures of the monomers used to produce the polyester. Show all atoms and bonds.



(2)

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**(4 marks)**

**4 (a)** There is a number of compounds with the molecular formula C<sub>4</sub>H<sub>8</sub>.

Explain how more than one compound can have the same molecular formula.

.....

.....

**(2 marks)**

**(b)** Draw the displayed formulae of two isomers with the formula C<sub>4</sub>H<sub>8</sub> that belong to different homologous series.

isomer 1	isomer 2

.....

.....

**(2 marks)**

- (c) i)** Describe a chemical test to show that compounds with the molecular formula C<sub>4</sub>H<sub>8</sub> belong to different homologous series.

(3)

- ii)** Explain how the results of the chemical test in part (i) proves that compounds with the molecular formula C<sub>4</sub>H<sub>8</sub> belong to different homologous series.

(1)

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**(4 marks)**

- (d)** Some organic compounds with the molecular formula C<sub>4</sub>H<sub>8</sub> can be hydrated to form alcohols.

- i) Give a chemical equation for this reaction.

(1)

- ii) State the name of this type of reaction.

(1)

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**(2 marks)**

**5 (a)** The diagram shows the formulae of some organic compounds.

A	B	C
$\text{CH}_4$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	$\text{CH}_2=\text{CH}-\text{CH}_3$
D	E	F
$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{Br} \\   \\ \text{H} \end{array}$	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	$\begin{array}{ccccc} \text{H} & & \text{H} & & \text{H} \\   & &   & &   \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\   & &   & &   \\ \text{H} & & \text{H} & & \text{H} \end{array}$

i) Explain which compound is not a hydrocarbon.

(1)

ii) Explain which compounds are shown as displayed formulae.

(1)

.....  
.....  
**(2 marks)**

**(b)** An example of the reaction of compound **B** with a halogen is shown.



i) State the condition needed for this reaction to occur

(1)

ii) Deduce the formula of compound **G**.

(1)

.....  
.....  
**(2 marks)**

- (c)** Compound **D** undergoes combustion to form a toxic colourless gas, a brown gas and one other product.

i) Give a chemical equation for this reaction.

(2)

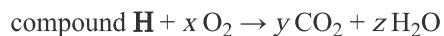
ii) Explain how the toxic colourless gas affects the respiratory system.

(2)

.....  
.....  
.....  
.....  
**(4 marks)**

- (d)** Compound **H** belongs to the same homologous series as compound **A**.

The complete combustion of one mole of compound **H** burns is represented by the equation



The numbers  $x$ ,  $y$  and  $z$  are used to balance the equation.

- i) One mole of compound **H** burning completely in oxygen produces 308 g of carbon dioxide and 144 g of water.

Calculate the values of  $y$  and  $z$ .

[ $M_r$  of  $\text{CO}_2 = 44$ ,  $M_r$  of  $\text{H}_2\text{O} = 18$ ]

(2)

$$y = \dots\dots\dots$$

$$z = \dots\dots\dots$$

- ii) Determine the molecular formula of the compound **H** and the value of  $x$ .

(2)

$$\text{molecular formula} = \dots\dots\dots$$

$$x = \dots\dots\dots$$

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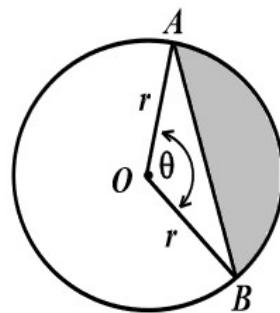
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**(4 marks)**



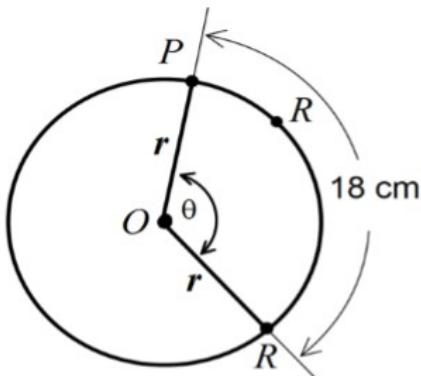
Student's Name:	Subject Group: Mathematics	MYP Year: 5
Time assigned: 1 hour	Time Taken:	Date: 09.02.21

7. The diagram shows a circle with centre  $O$  and radius  $r$ . The central angle  $AOB$  has a measure of  $\theta$  radians. Show that the area of the shaded region is  $\frac{1}{2}r^2(\theta - \sin \theta)$ .

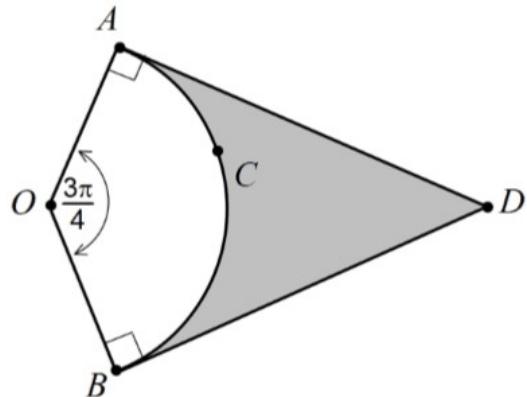


8. The diagram below shows a circle with radius  $r$  and centre  $O$ . The central angle  $POR = \theta$ .

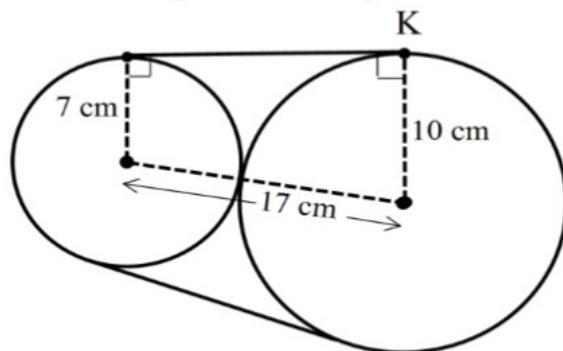
The length of the minor arc  $PR$  is 18 cm. The area of the sector  $OPSR$  is  $108 \text{ cm}^2$ . Find the value of  $r$  and the value of  $\theta$ .



9.  $ACB$  is an arc of a circle with centre  $O$  and radius 8 cm.  $AD$  and  $BD$  are tangents to the circle at  $A$  and  $B$  and angle  $AOB = \frac{3\pi}{4}$ . Find the area enclosed by arc  $ACB$  and line segments  $AD$  and  $BD$  (region shaded in the diagram below).



10. Two circles, one of radius 10 cm and one of radius 7 cm, are positioned such that they intersect at a single point as shown in the diagram below. A length of string is wrapped around both circles starting at point K and finishing at point K. Find the length of the string.



[ diagram not to scale ]





# CIE IGCSE Chemistry



## Exothermic & Endothermic Reactions

### Contents

- \* Endothermic & Exothermic Reactions
- \* Enthalpy Change & Activation Energy
- \* Bond Breaking & Bond Forming



Your notes

## Endothermic & Exothermic Reactions

### Exothermic & endothermic reactions

#### Heat exchange in reactions

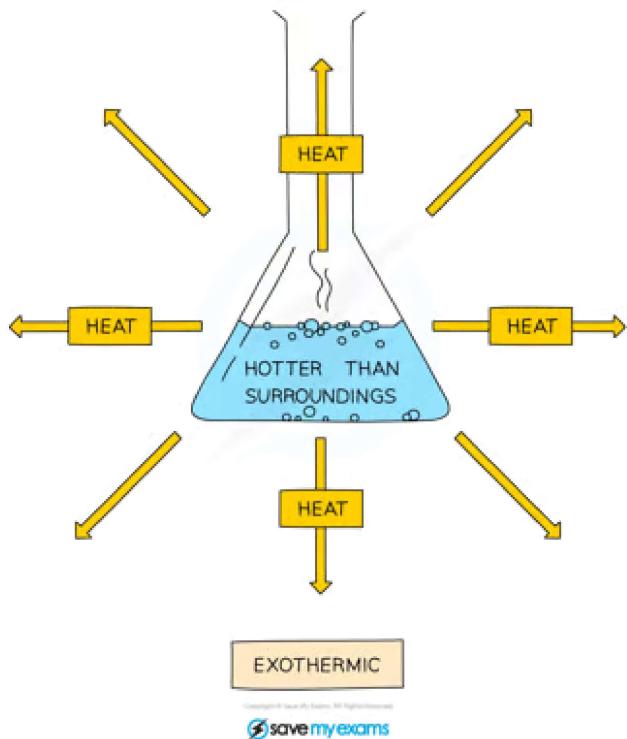
- Chemical reactions occur so that elements can achieve a more stable energy state by gaining a full outer shell of electrons
  - This is done by **chemical bonding**
- This process involves the **transfer of thermal energy** into and out of reaction mixtures
- The terms used to describe this are:
  - **System:** the reacting chemicals
  - **Surroundings:** anything other than the chemicals reacting
- The energy within the system comes from the **chemical bonds** themselves which could be considered as tiny stores of chemical energy

#### Exothermic reactions

- In exothermic reactions, thermal energy is **transferred** from the chemical energy store of the chemical system to the surroundings
  - The energy of the system decreases, which means that the energy change is **negative**
  - The temperature of the surroundings increases because thermal energy is **given out / released**
- The overall transfer is from the system to the surroundings



Your notes



**Diagram showing the transfer of heat energy outwards from an exothermic reaction**

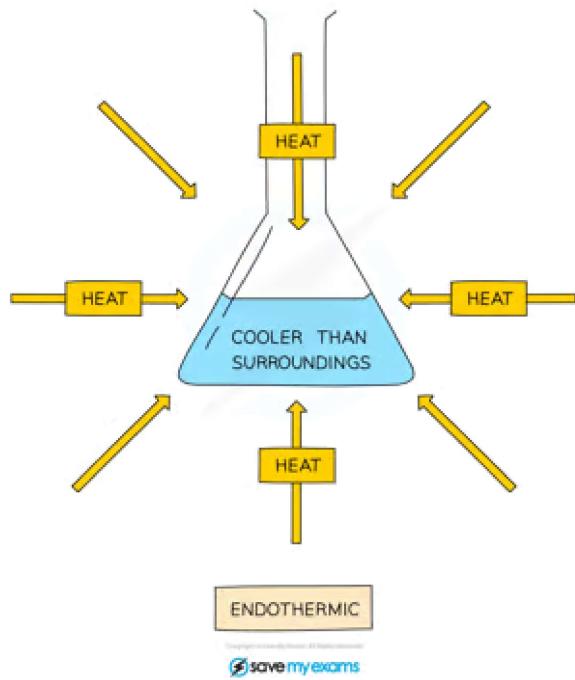
- Typical examples of exothermic reactions include:
  - Combustion
  - Oxidation
  - Neutralisation
- Hand warmers used in the wintertime are based on the release of heat from an exothermic reaction
- Self-heating cans of food and drinks such as coffee and hot chocolate also use exothermic reactions in the bases of the containers

## Endothermic reactions

- In endothermic reactions, thermal energy is **transferred** from the surroundings system to the system surroundings
  - The energy of the system increases, which means that the energy change is **positive**
  - The temperature of the surroundings decreases because thermal energy is **taken in / absorbed**
- The overall transfer is from the surroundings to the system



Your notes



**Diagram showing the transfer of heat energy from the surroundings into an endothermic reaction**

- Endothermic reactions are less common than exothermic reactions
- Typical examples of endothermic reactions include:
  - Electrolysis
  - Thermal decomposition
  - The first stages of photosynthesis
- **Cold packs** for sports injuries are based on endothermic reactions, designed to take heat away from a recently injured area to prevent swelling



Your notes

## Worked example

A student was investigating the temperature change for four different chemical reactions. The table shows the chemicals that the student combined for each reaction along with the initial and final temperatures of the reaction.

Experiment	Chemicals		Initial temperature (°C)	Final temperature (°C)
1	10 cm <sup>3</sup> NaOH	10 cm <sup>3</sup> HCl	19	21
2	10 cm <sup>3</sup> NaHCO <sub>3</sub>	2 g citric acid	20	16
3	10 cm <sup>3</sup> CuSO <sub>4</sub>	0.5 g Mg powder	20	26
4	10 cm <sup>3</sup> H <sub>2</sub> SO <sub>4</sub>	3 cm Mg ribbon	19	31

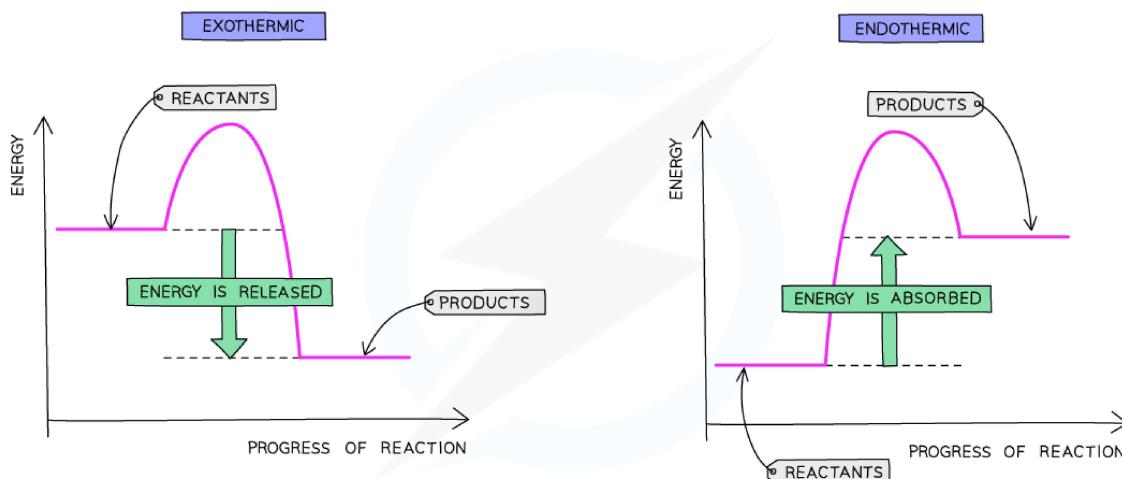
Explain whether each reaction is endothermic or exothermic.

### Answers:

- Reactions 1, 3 and 4 are exothermic reactions because they show a temperature increase
- Reaction 2 is an endothermic reactions because it shows a temperature decrease

## Reaction pathway diagrams

- Reaction pathway diagrams** are graphical representations of the relative energies of the reactants and products in chemical reactions
- On a reaction pathway diagram:
  - Progress of the reaction is shown on the x-axis
  - Energy is shown on the y-axis
  - The difference in height between the energy of reactants and products is the **overall energy change** of a reaction



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### Reaction pathway diagram of an exothermic reaction and an endothermic reaction

- In exothermic reactions:
  - Energy is given out to the surroundings
  - The energy of the products will therefore be **lower** than the energy of the reactants
  - The overall energy change is **negative**
  - This is represented on the reaction profile with a downwards-arrow as the energy of the products is lower than the reactants
- In endothermic reactions:
  - Energy is taken in from the surroundings
  - The energy of the products will be **higher** than the energy of the reactants
  - The overall energy change is **positive**
  - This is represented on the reaction profile with an upwards-arrow as the energy of the products is higher than the reactants

#### Exam Tip

- To help you remember whether a chemical system is exothermic or endothermic:
  - In **E**xothermic reactions heat **E**xits the system and in **E**ndothermic reactions heat **E**nters the system.
  - Exothermic reactions always give off heat and they feel hot
  - Endothermic reactions always take heat in and they feel cold.
- Core candidates will be expected to interpret reaction pathway diagrams
- Extended candidates will be expected to draw and interpret reaction pathway diagrams



Your notes

## Enthalpy Change & Activation Energy

### Enthalpy change & activation energy

Extended tier only

- For atoms or particles to react with each other in a chemical system they must **collide** together
- A number of factors affect the success of a collision:
  - **Energy**
  - **Orientation**
  - **Number of collisions per second** – the **frequency** of collisions

### What is activation energy?

- In terms of the energy of collisions, there is a **minimum amount of energy** required for a successful collision
  - A successful collision is where the particles in the reactant(s) are rearranged to form the products
- This minimum amount of energy is called the **activation energy**,  $E_a$
- Different reactions have different activation energies, depending on the chemical identities involved
- Reactions with higher activation energies require more energy to start than those with lower activation energies

### What is enthalpy change?

- The **transfer of thermal energy** during a reaction is called the **enthalpy change**,  $\Delta H$ , of the reaction.
- $\Delta H$  is:
  - Positive for an endothermic reaction
  - Negative for an exothermic reaction

## Reaction pathway diagrams

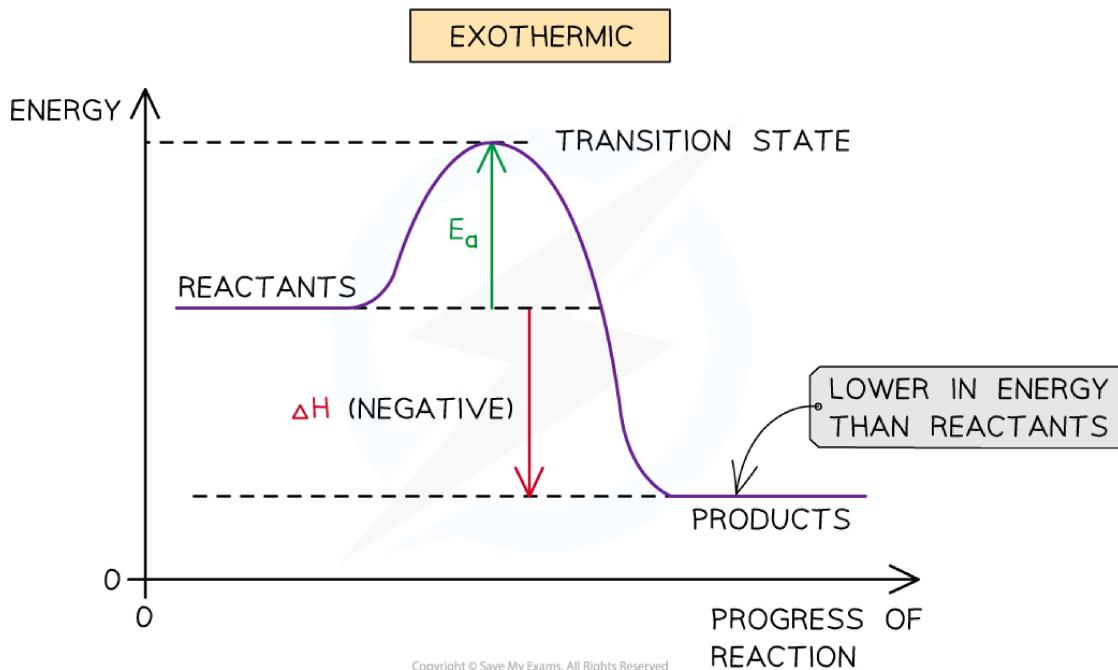
Extended tier only



Your notes

### Exothermic reactions

- A reaction is **exothermic** when more energy is released forming new bonds for the products than absorbed breaking the bonds in the reactants
- So, the products have less energy than the reactants
  - This means that the change in energy is negative
- Therefore, an exothermic reaction has a **negative** value for enthalpy,  $\Delta H$
- The reaction pathway diagram for an exothermic reaction is:



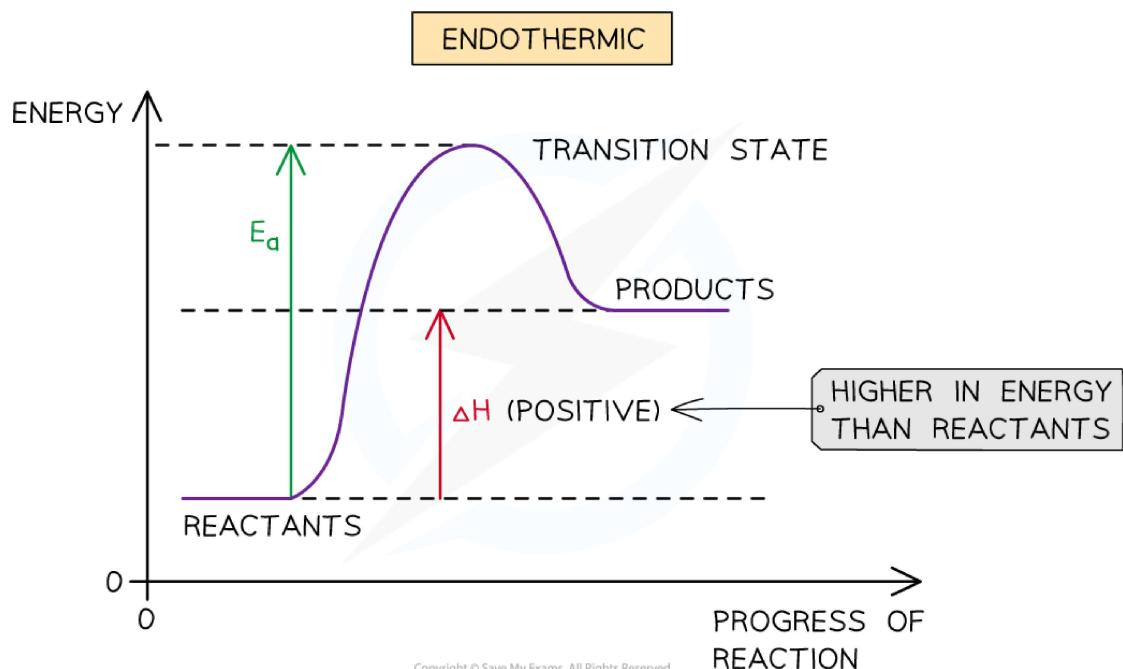
*The reaction pathway diagram for exothermic reactions*

### Endothermic reactions

- A reaction is **endothermic** when more energy is absorbed breaking the bonds in the reactants than released forming new bonds for the products
- So, the products have more energy than the reactants
  - This means that the change in energy is positive
- Therefore, an endothermic reaction has a **positive** value for enthalpy,  $\Delta H$
- The reaction pathway diagram for an endothermic reaction is:



Your notes



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*The reaction pathway diagram for endothermic reactions.*

### Exam Tip

You **must** be able to draw these pathway diagrams and label the following parts:

- Reactants
- Products
- Enthalpy change of the reaction,  $\Delta H$
- Activation energy,  $E_a$



Your notes

## Bond Breaking & Bond Forming

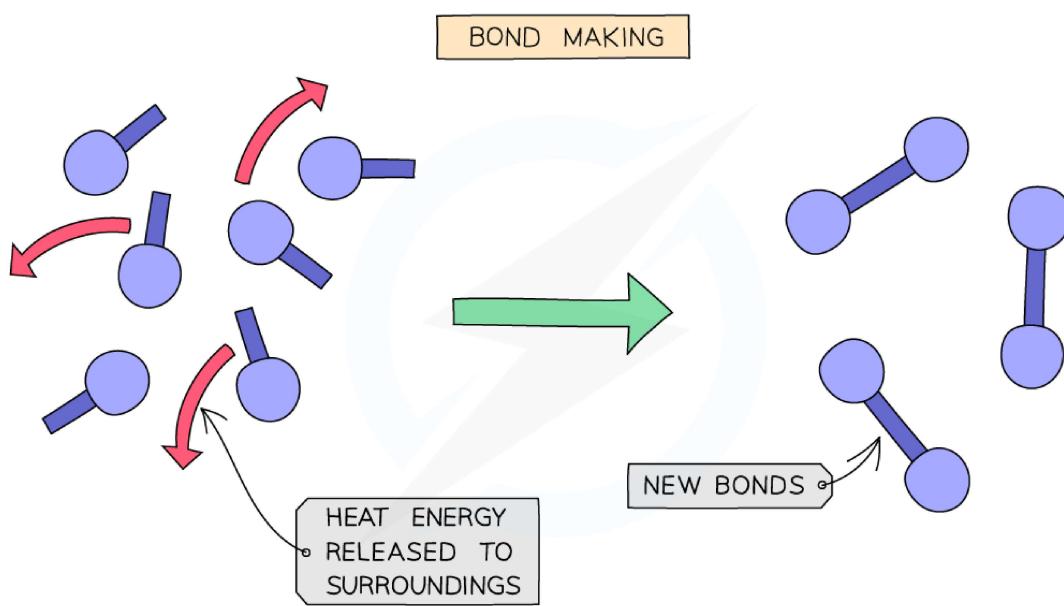
### Bond breaking & bond forming

Extended tier only

- Whether a reaction is endothermic or exothermic depends on the difference between the energy needed to **break** existing bonds and the energy released when the new bonds are **formed**
- Bond breaking** is always an **endothermic** process as energy needs to be taken in from the surroundings to break the chemical bonds
- Bond making** is always an **exothermic** process as energy is transferred to the surroundings as the new bond is formed

### Exothermic reactions

- If more energy is released than is absorbed, then the reaction is **exothermic**
- More energy is released when new bonds are formed than energy required to break the bonds in the reactants
- The change in energy is negative since the products have less energy than the reactants
- Therefore, an exothermic reaction has a **negative  $\Delta H$**  value
  - This can be shown in [reaction pathway diagrams](#) and calculations



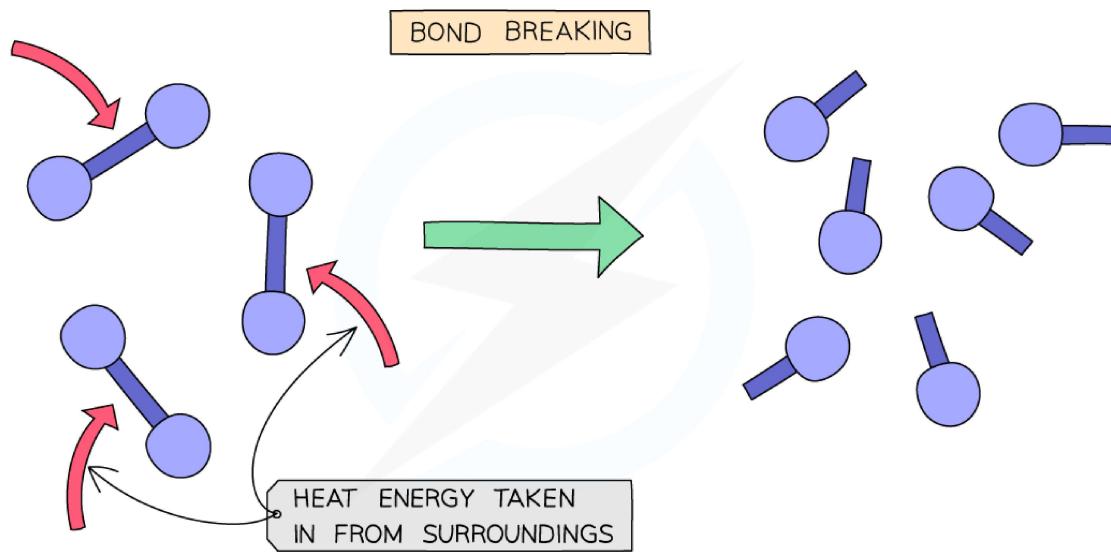
Making new chemical bonds releases energy which radiates outwards from the reaction to the surroundings in the form of heat



Your notes

## Endothermic reactions

- If more energy is absorbed to break bonds than is released to form new bonds, this reaction is **endothermic overall**
- The change in energy is positive since the products have more energy than the reactants
- The symbol  $\Delta H$  is used to show the change in heat energy
  - $H$  is the symbol for enthalpy, which is a measure of the total **heat of reaction** of a chemical reaction
- Therefore, an endothermic reaction has a **positive  $\Delta H$**  value
  - This can be shown in [reaction pathway diagrams](#) and calculations

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Breaking chemical bonds requires energy which is taken in from the surroundings in the form of heat

# Key

## Ideal Gas Law Worksheet PV = nRT

Use the ideal gas law, "PV=nRT", and the universal gas constant  $R = 0.0821 \frac{L \cdot atm}{K \cdot mol}$  to solve the following problems:

If pressure is needed in kPa then convert by multiplying by  $101.3 \text{kPa} / 1 \text{atm}$  to get

$$R = 8.31 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mole}}$$

- 1) If I have 4 moles of a gas at a pressure of 5.6 atm and a volume of 12 liters, what is the temperature?

$$PV = nRT$$

$$T = \frac{PV}{nR} = \frac{(5.6 \text{ atm})(12 \text{ L})}{4 \text{ mol} \cdot 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}} = 204.63 \text{ K}$$

$$T = 204.63 \text{ K}$$

- 2) If I have an unknown quantity of gas at a pressure of 1.2 atm, a volume of 31 liters, and a temperature of  $87^\circ\text{C}$ , how many moles of gas do I have?

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{1.2 \text{ atm} \cdot 31 \text{ L}}{0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 300 \text{ K}} = 1.2586 \text{ mol}$$

$$n = 1.2586 \text{ mol}$$

- 3) If I contain 3 moles of gas in a container with a volume of 60 liters and at a temperature of 400 K, what is the pressure inside the container?

$$PV = nRT$$

$$P = \frac{nRT}{V} = \frac{3 \text{ mol} \cdot 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 400 \text{ K}}{60 \text{ L}} = 1.642 \text{ atm}$$

$$\text{or } P = 166.24 \text{ kPa}$$

$$P = 1.642 \text{ atm}$$

- 4) If I have 7.7 moles of gas at a pressure of 0.09 atm and at a temperature of  $56^\circ\text{C}$ , what is the volume of the container that the gas is in?

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{7.7 \text{ mol} \cdot 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 329 \text{ K}}{0.09 \text{ atm}} = 2310.93 \text{ L}$$

$$V = 2310.93 \text{ L}$$

- 5) If I have 17 moles of gas at a temperature of  $67^\circ\text{C}$ , and a volume of 88.89 liters, what is the pressure of the gas?

$$PV = nRT$$

$$P = \frac{nRT}{V} = \frac{17 \text{ mol} \cdot 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 390 \text{ K}}{88.89 \text{ L}} = 5.34 \text{ atm}$$

$$P = 5.34 \text{ atm}$$

$$P = 540.61 \text{ kPa}$$

or

- 6) If I have an unknown quantity of gas at a pressure of 0.5 atm, a volume of 25 liters, and a temperature of 300 K, how many moles of gas do I have?

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{0.5 \text{ atm} \cdot 25 \text{ L}}{0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 300 \text{ K}} = 0.5075 \text{ mol}$$

$$n = 0.5075 \text{ mol}$$

- 7) If I have 21 moles of gas held at a pressure of 78 atm and a temperature of 900 K, what is the volume of the gas?

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{21 \text{ mol} \cdot 0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \cdot 900 \text{ K}}{78 \text{ atm}}$$

$$V = 19.89 \text{ L}$$

- 8) If I have 1.9 moles of gas held at a pressure of 5 atm and in a container with a volume of 50 liters, what is the temperature of the gas?

$$PV = nRT$$

$$T = \frac{PV}{nR} = \frac{5 \text{ atm} \cdot 50 \text{ L}}{1.9 \text{ mol} \cdot 0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}}$$

$$T = 1602.67 \text{ K}$$

- 9) If I have 2.4 moles of gas held at a temperature of 97 °C and in a container with a volume of 45 liters, what is the pressure of the gas?

$$PV = nRT$$

$$P = \frac{nRT}{V} = \frac{2.4 \text{ mol} \cdot 0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \cdot 370 \text{ K}}{45 \text{ L}}$$

$$P = 1.62 \text{ atm}$$

or

$$P = 164.06 \text{ kPa}$$

- 10) If I have an unknown quantity of gas held at a temperature of 1195 K in a container with a volume of 25 liters and a pressure of 560 atm, how many moles of gas do I have?

$$PV = nRT$$

$$n = \frac{RT}{PV} = \frac{0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \cdot 1195 \text{ K}}{560 \text{ atm} \cdot 25 \text{ L}}$$

$$n = 0.007008 \text{ mol}$$

- 11) If I have 0.275 moles of gas at a temperature of 75 K and a pressure of 1.75 atmospheres, what is the volume of the gas?

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{0.275 \text{ mol} \cdot 0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \cdot 75 \text{ K}}{1.75 \text{ atm}}$$

$$V = 0.9676 \text{ L}$$

- 12) If I have 72 liters of gas held at a pressure of 3.4 atm and a temperature of 225 K, how many moles of gas do I have?

$$PV = nRT$$

$$n = \frac{RT}{PV} = \frac{0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \cdot 225 \text{ K}}{72 \text{ L} \cdot 3.4 \text{ atm}}$$

$$n = 0.07546 \text{ mol}$$



Oakridge International School

# MYP 4&5 Chemistry - 8 - copy - copy

## IB Middle Years Chemistry

Grade: Grade 10

Criteria:  A 25  B 26  C 25  D 24

Total: 100 points

Authors: Punitha Neelamegam

## Question 1

### Knowing and understanding

This task (questions 1 and 2) addresses the key concept of **systems** and focuses on **criterion A** (Knowing and understanding).

Esters are organic compounds commonly known for their pleasant fruity or floral aromas.

Perceived flavour is the result of complex interactions between all the volatile and non-volatile compounds present in wine.

**Ethyl acetate** ( $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$ ) and **Ethyl hexanoate** ( $\text{CH}_3(\text{CH}_2)_4\text{COOC}_2\text{H}_5$ ) are some of the common compounds found in alcoholic beverages. Ethyl hexanoate is present in all beers. Concentrations of ethyl hexanoate vary from beer to beer. Ethyl acetate is produced by yeast and at low levels can contribute 'fruity' aroma properties and add complexity to wine.



Q 1.1 **Identify** the functional group present in both the compounds.

A 1

Teacher's Explanation

Ester

Q 1.2 **Select** the general formula of esters.

A 1

A  $R-O-R'$

B  $R-O-O-R'$

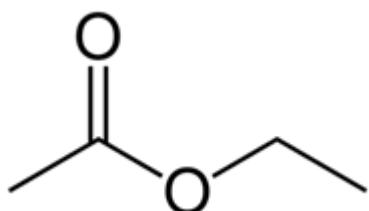
C  $R-C-O-O-R'$

D  $R-O-X$

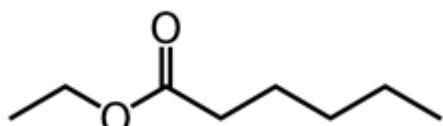
Q 1.3 Draw the structure of ethyl acetate and ethyl hexanoate.

A 2

Teacher's Explanation



Ethyl acetate

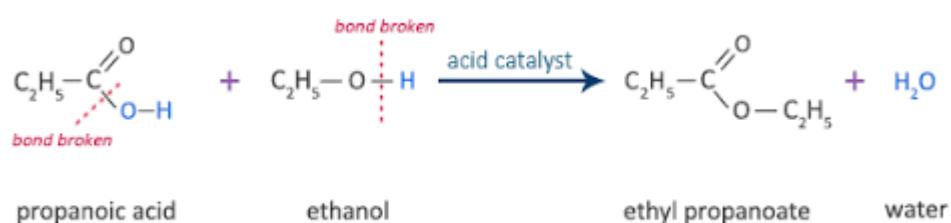


Ethyl hexanoate

Q 1.4 Write down the products along with its structures when propanoic acid reacts with ethanol.

A 4

Teacher's Explanation



Q 1.5 State the name of the reaction in Q 1.4.

A 1

Teacher's Explanation

## Esterification reaction

Q 1.6 Identify the ion present in the solution of any carboxylic acid.

A 1

A  $\text{H}^+$

B  $\text{OH}^-$

C  $\text{H}^-$

## Question 2

A cell refers to a single anode and cathode separated by electrolyte used to produce a voltage and current. A battery can be made up of one or more cells.

The most common type of lithium cell used in consumer applications uses metallic lithium as the anode and manganese dioxide as the cathode, with a salt of lithium dissolved in an organic solvent as the electrolyte.

Q 2.1 **State** the number of protons, electrons and neutrons in  $\text{Li}^+$  ion.

A 3

Teacher's Explanation

Proton: 3

Electron: 2

Neutron: 4

Q 2.2 **State** the oxidation state of Manganese in Manganese dioxide also **write down** its formula.

A 1

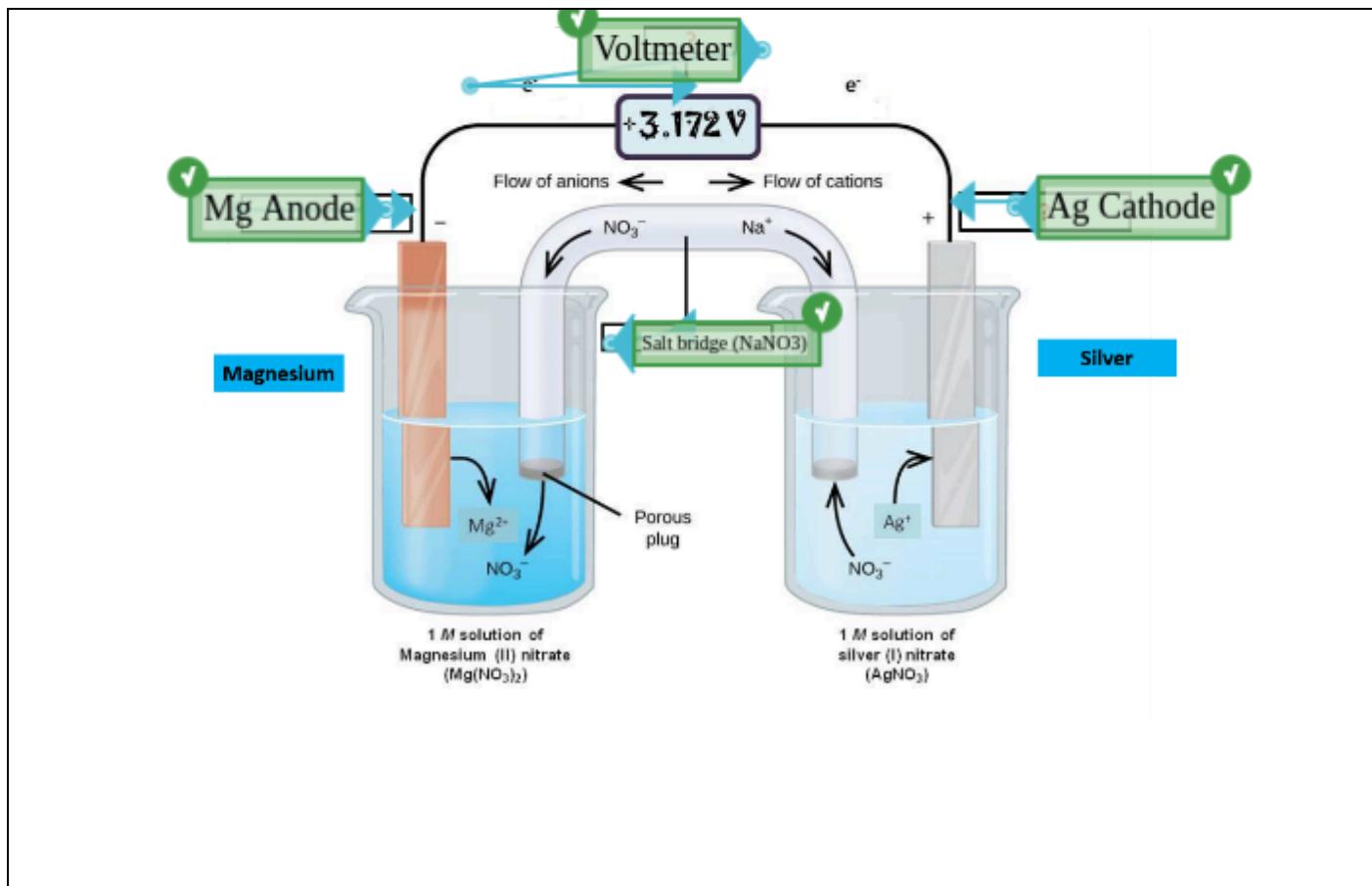
Teacher's Explanation

$\text{MnO}_2$

Oxidation state: +4

Q 2.3 On the basis of your knowledge and understanding **label** the diagram of the voltaic cell. **Determine** the direction of flow of electrons.

A 5



#### Teacher's Explanation

Electron flows from Mg anode to Ag cathode

Q 2.4

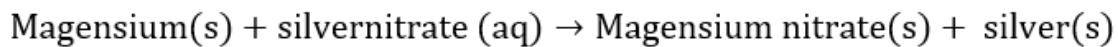
A 2

**Find** the missing terms and complete the following sentence

Oxidation is **Loss** of electrons, whereas reduction is **gain** of electrons.

Q 2.5 **Write down** the balanced redox reaction for the below reaction. **Identify** oxidising as well as reducing agent.

A 4



## Teacher's Explanation



$\text{AgNO}_3$  : Oxidising agent

Mg : Reducing agent

## Question 3

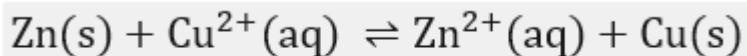
### Investigation skills

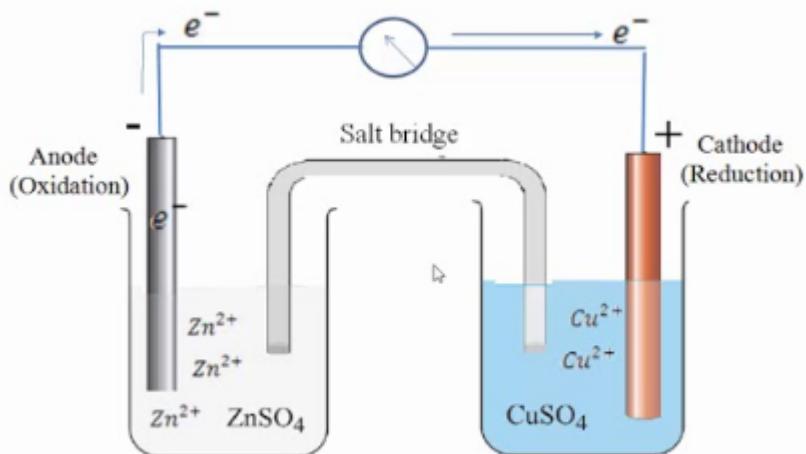
This task (questions 3 to 4) addresses the key concept of **relationships** and focuses on **criterion B** (Inquiring and designing) and **criterion C** (Processing and evaluating). In this task you will investigate the relationships in chemistry.

Daniell Cell is an early example of a galvanic cell producing electricity through metal displacement.

A battery is a device that stores chemical energy and converts it to electrical energy. The chemical reactions in a battery involve the flow of electrons from one material (electrode) to another, through an external circuit.

A Daniell cell is the best example of a galvanic cell which converts chemical energy into electrical energy. The Daniell cell consists of two electrodes of dissimilar metals, Zn and Cu; each electrode is in contact with a solution of its own ion; Zinc sulphate and copper sulphate respectively. Consider the following data for the Daniel cell which is defined by the following reaction:





Temperature (°C)	$E^0(V)$
0	1.128
10	1.0971
20	1.0929
25	1.0913
30	1.0901
40	1.0887

Q 3.1 **State** a suitable hypothesis that could be tested using the data in the table.

B 1

#### Teacher's Explanation

If the temperature is increased, the standard electrode potential of the cell will be decreased because a greater amount of energy will be dissipated as heat, which in turn can decrease the effective potential difference between the two electrodes, leading to a decrease in the standard electrode potential of the cell.

**Q 3.2** **Suggest** an improvement to the method that would enhance the accuracy and credibility of the outcome.

C 1

Teacher's Explanation

Increase the number of trials.

**Q 3.3** **Select** a suitable graph for presenting the data.

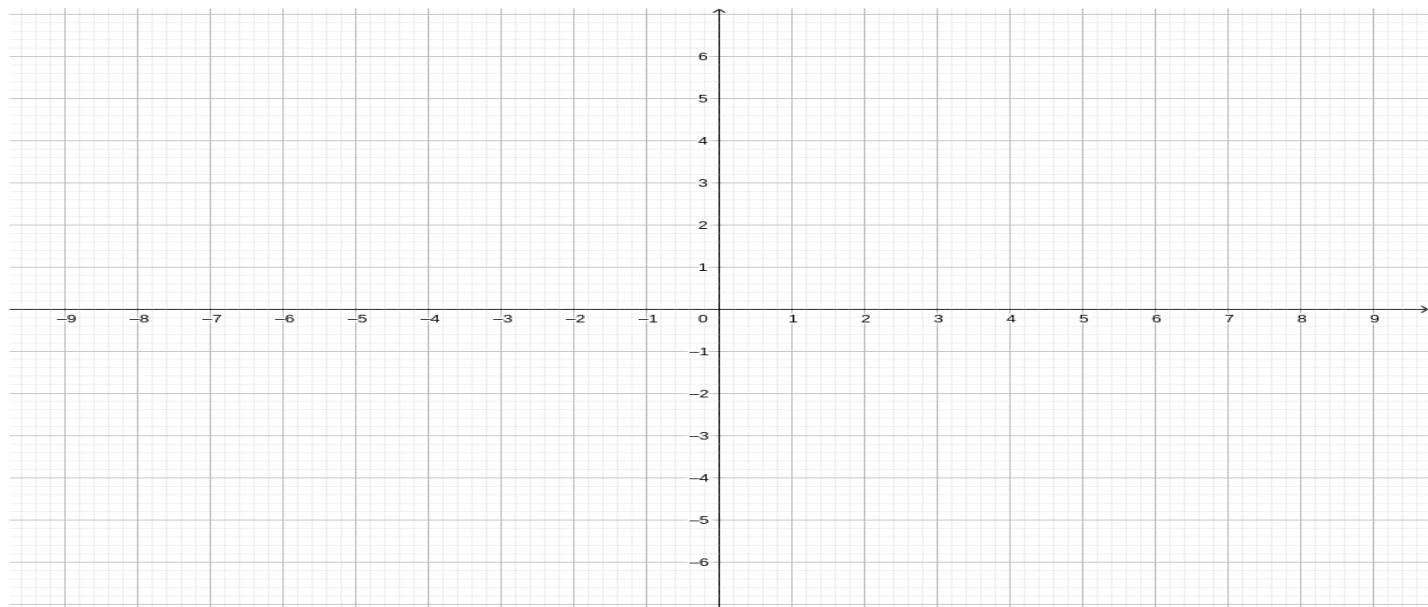
C 1

A Scattered graph

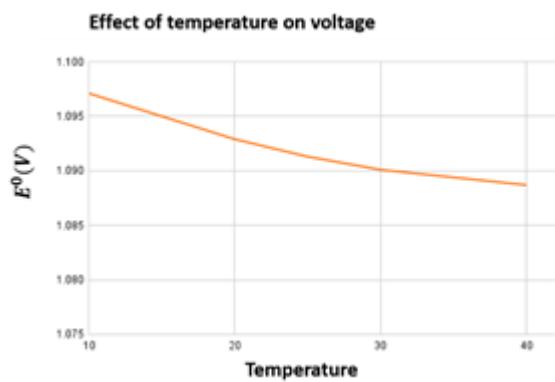
B Line graph

Q 3.4 Present the data in the graph. Label the X and Y axis and give an appropriate heading to your graph.

C 6

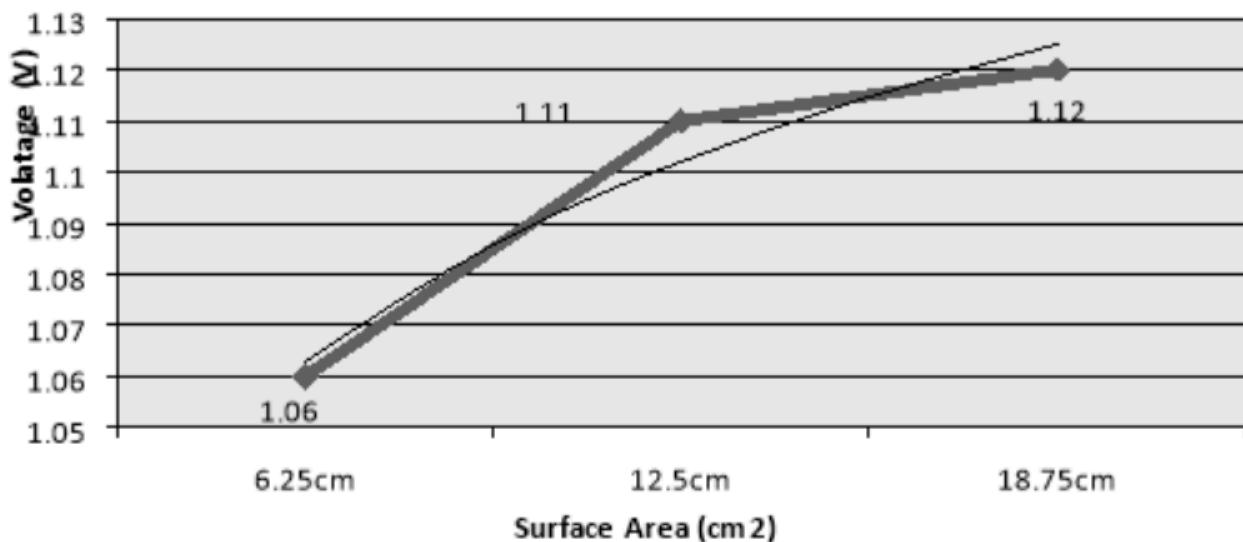


#### Teacher's Explanation



Content type: Image

## Graph 1. Copper and Zinc Cell



Copper and zinc cell

Q 3.5 **State** a suitable research question that could be examined in relation to the given graph.

B 1

Teacher's Explanation

How does altering the surface area of a cell affect the voltage generated in an electrochemical cell?

Q 3.6 **Present** the data depicted in the graph in an appropriate table.

C 3

Teacher's Explanation

Surface Area (l)	Voltage(V)
6.25 cm	1.06
12.5 cm	1.11
18.75 cm	1.12

Q 3.7 Using the information in the above task, **identify** the variables.

B 3

- Independent variable
- Dependent variable
- Control variable

#### Teacher's Explanation

- Independent variable : Surface area
- Dependent variable: Voltage
- Control variable: Temperature / concentration

Q 3.8 **Design** a laboratory procedure that examines the operation of a voltaic cell containing copper sulphate and magnesium sulphate. Your response should include the following aspects:

B 9

- Formulation of the redox equation involved in the cell
- Inventory of apparatus and substances required
- Description of the experimental approach
- Record of the observations to be noted
- Explanation of the safety precautions that will be taken during the procedure.

#### Teacher's Explanation

	1	2	3
Equipment	Some equipment including test tube is listed	Appropriate and complete equipment is listed	
Method used	Attempt at a method	All the methods including fine details are mentioned	
Reaction	One reaction is mentioned	Both the reactions are mentioned	Both balanced reactions are mentioned
Observations/Safety method	A safety precaution is stated	A safety precaution is stated and linked to hazard and all the observations mentioned	

## Question 4

Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration down the concentration gradient.

Content type: Video

Video 4.1



This item includes interactive content. Please refer to the digital version of this assessment to view this item.

**Q 4.1 Design** an experiment using the below setup to study the diffusion rates of Hydrochloric acid and Ammonia.

B 12

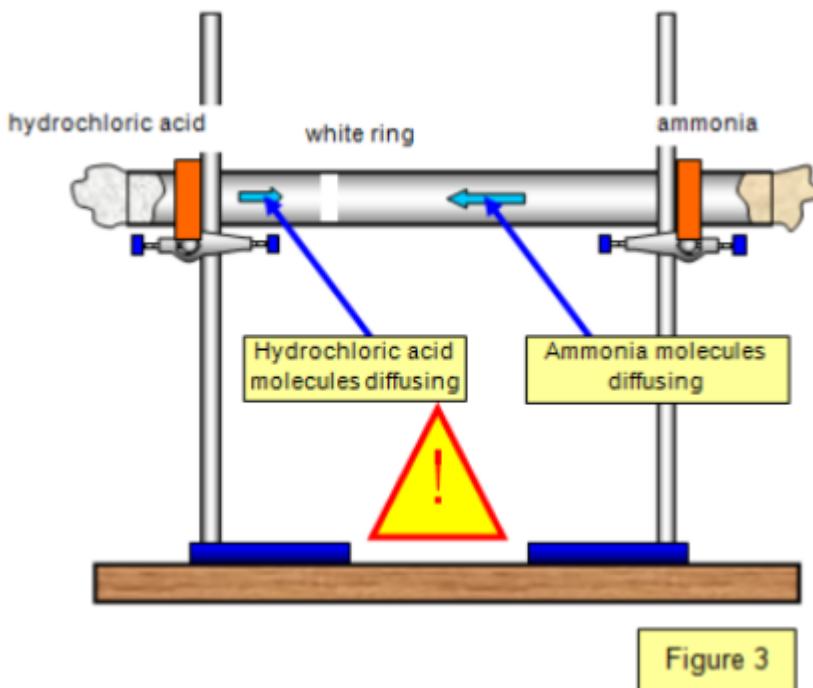


Figure 3

In your answer you should include:

- A list of equipment you will use
- Details of the data you will collect
- How will you ensure your method is safe

### Teacher's Explanation

<ul style="list-style-type: none"><li>• Some equipment is listed - Cotton wool balls</li><li>• Attempt at data collection</li></ul>	2 – 4
<ul style="list-style-type: none"><li>• Some equipment including test tube is listed – beakers, metal tweezers, Dropping pipettes</li><li>• Details of data mentioned</li><li>• A safety precaution is stated</li></ul>	4 – 8
<ul style="list-style-type: none"><li>• Appropriate and complete equipment is listed: Cotton wool balls, beakers, metal tweezers, Two clamps and stands</li><li>• Details of data mentioned</li><li>• A safety precaution is stated and linked to hazard</li></ul>	8 - 12

**Q 4.2 Using the formula ,**

C 8

$$\text{Rate} = \frac{\text{Distance in mm}}{\text{Time in s}}$$

**Identify** the missing terms and complete the table.

Elapsed time (minutes), and time on clock for each	Potassium permanganate, Distance (mm)	Potassium Permanganate, Rate (distance in mm/time in s)	Methyl orange, Distance (mm)	Methyl Orange, Rate (distance in mm/ time in s)
15	8		5	
30	10		6	
45	12		10	
60	13		11	

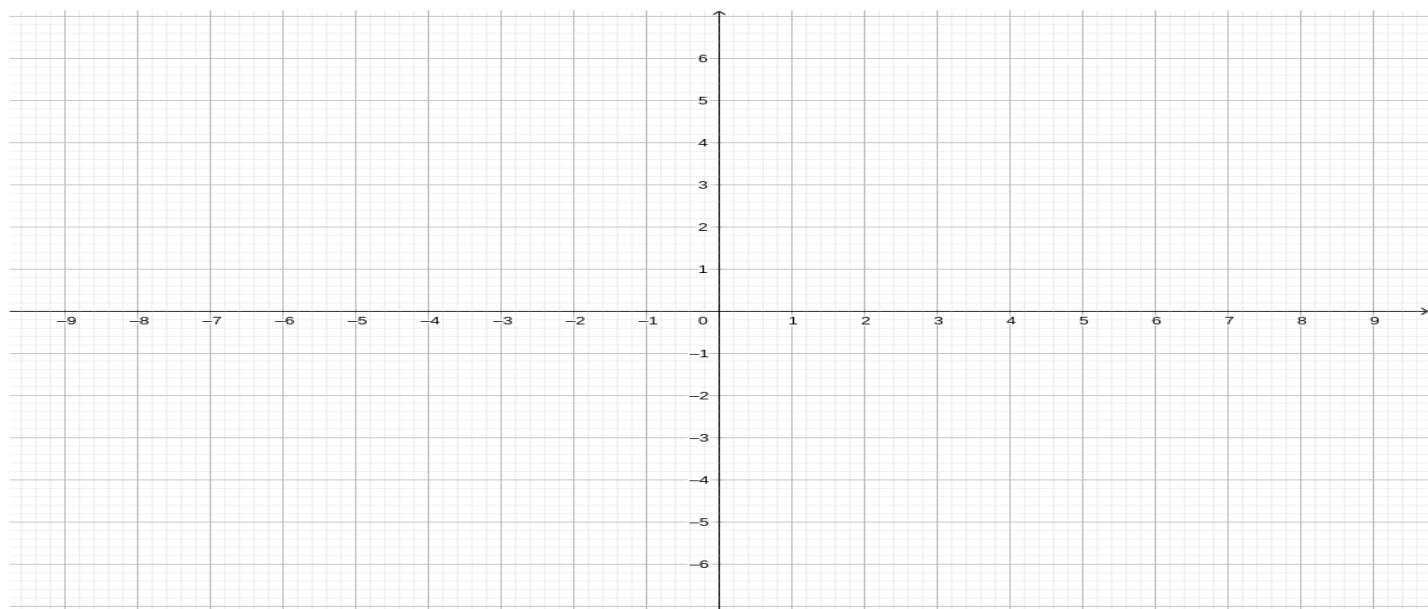
**Teacher's Explanation**

Elapsed time (minutes), and time on clock for each	Potassium permanganate, Distance (mm)	Potassium Permanganate, Rate (distance in mm/time in s)	Methyl orange, Distance (mm)	Methyl Orange, Rate (distance in mm/ time in s)
15	8	0.008	5	0.0055
30	10	0.0055	6	0.0033
45	12	0.0044	10	0.0037
60	13	0.0036	11	0.0036

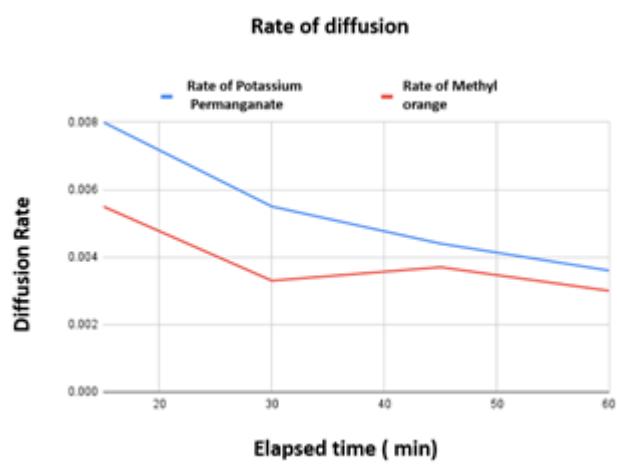
**Q 4.3** Plot a suitable graph that shows the relationship between time and diffusion rate.

C 6

Ensure that the X and Y axes are correctly labelled with their respective units.



#### Teacher's Explanation



## Question 5

### Applying science

The global context is **globalization and sustainability**.

This task (questions 5 and 6) addresses the key concept of **key concept** and assesses **criterion D** (Reflecting on the impacts of science).

Human efforts can create deep impacts on environment and society.

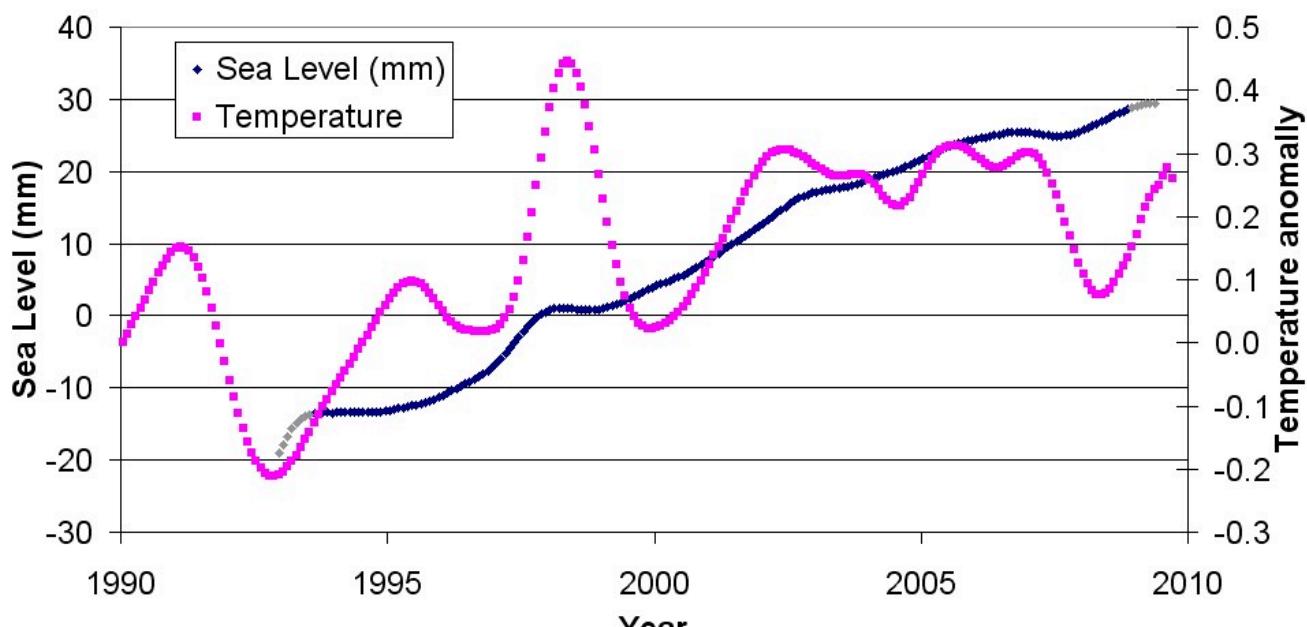
Global mean sea level has risen about 8–9 inches (21–24 centimeters) since 1880, with about a third of that coming in just the last two and a half decades.

Content type: Image



Places that will disappear with rising sea levels

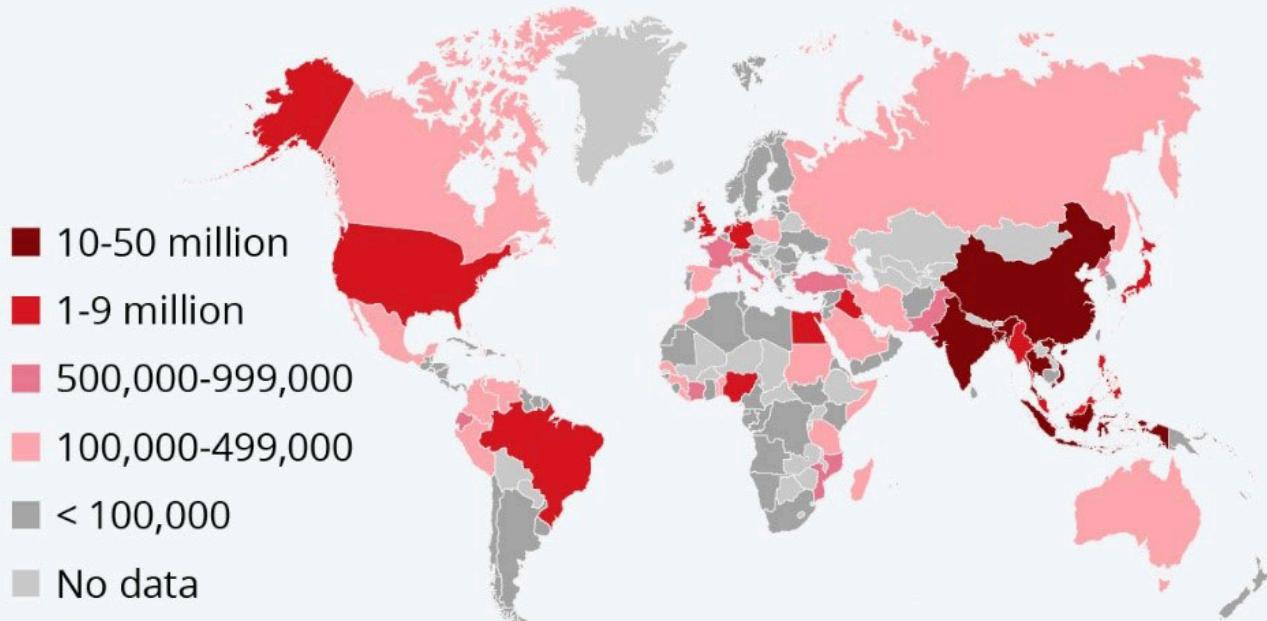
### Sea Level and Temperature (one year FWHM gaussian filtered, 12 month interpolated)



Sea level and temperature

# Where Most People Are Affected by Rising Sea Levels

Number of people per country living on land expected to be under sea level by 2100\*



\* assuming a rise in sea levels of 50-70 cm (2° C temperature increase/not taking into account ice sheet instability)

People and rising sea level

Q 5.1 Referring to the world map shown above and the information provided in the task, **discuss** and **evaluate** the implication of rising global temperature. In your answer you should include:

D 12

- The impact on the people
- Wider Impact on the community
- Causes of the rising sea level
- A concluding appraisal of all of the issues you have discussed

## Teacher's Explanation

<ul style="list-style-type: none"><li>• Briefly mentioned the impact on the people</li><li>• A comment about the impact on the environment for eg. – Heat illness / Heat stroke</li></ul>	2 – 4
<ul style="list-style-type: none"><li>• Briefly mentioned the impact on the people</li><li>• Briefly mentioned the wider impact on the community</li><li>• A comment about the economic impact on the community for eg. – extreme weather condition / drought like condition</li></ul>	4 – 6
<ul style="list-style-type: none"><li>• Account of more than one impact on the people</li><li>• Account of more than one impact on the community</li><li>• Account for the cause of rising sea level</li><li>• Detailed list of causes for eg. – Global warming</li></ul>	6 – 8
<ul style="list-style-type: none"><li>• Account of more than one impact on the people</li><li>• Account of more than one impact on the community</li><li>• Account for the cause of rising sea level</li><li>• Detailed list of causes for eg. – Global warming</li><li>• A concluding appraisal linking all the issues discussed above</li></ul>	8 - 12

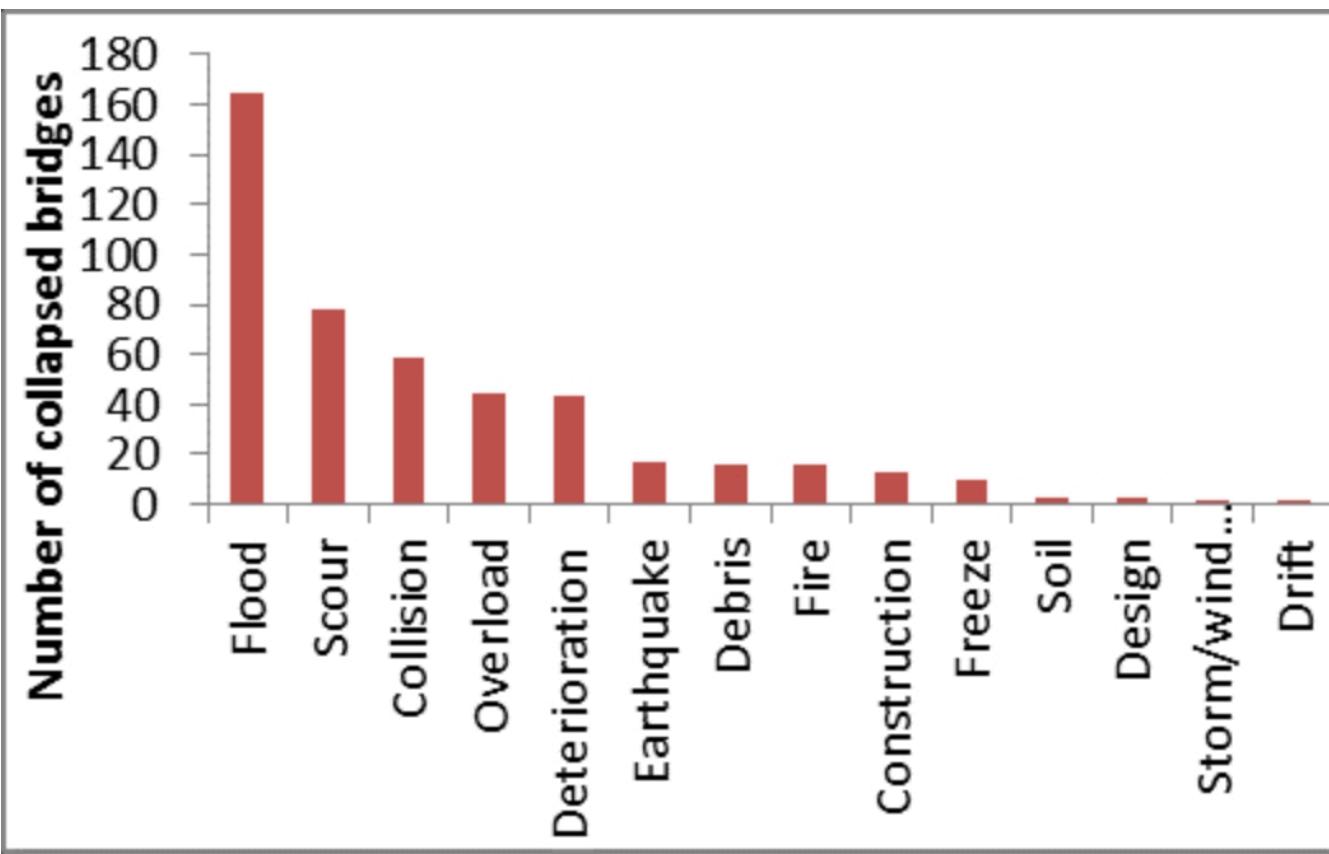
## Question 6

Corrosion is the deterioration of materials due to chemical or electrochemical reactions with their environment.

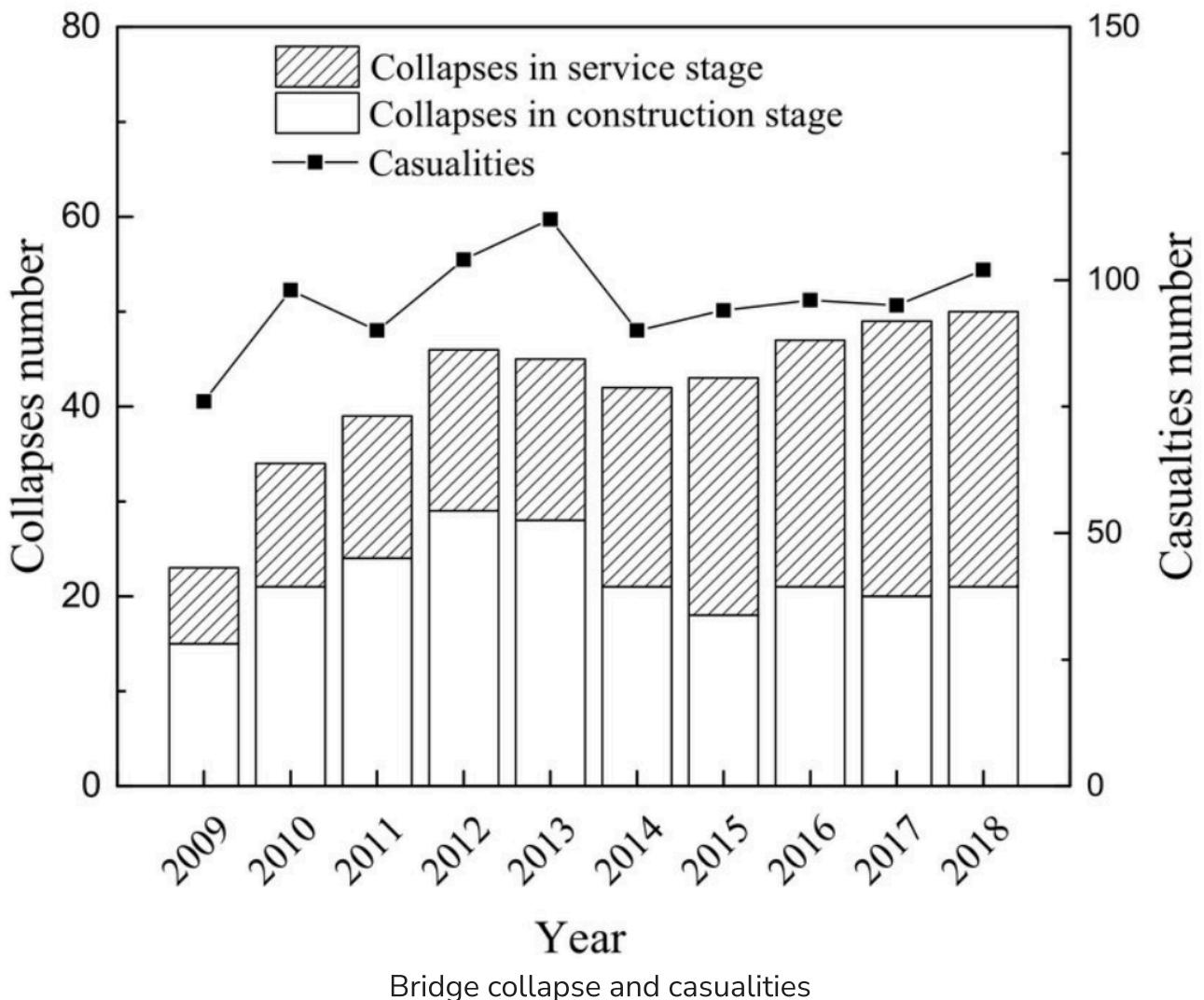
Corrosion is a natural process that converts a refined metal into a more chemically stable form such as oxide, hydroxide, or sulphide. It is the gradual destruction of materials (usually a metal) by chemical and/or electrochemical reaction with their environment.

Experts find that more than 95 percent of the structural damage on bridges can be traced back to some form of corrosion. It's a particularly big factor on the four out of 10 bridges in the united states that are more than 50 years old, because most have been treated to prevent it.

Content type: Image



Data on the number of bridges collapsed



<b>Bridge</b>	<b>Country</b>	<b>Date</b>	<b>Construction type, use of bridge</b>	<b>Casualties</b>
Boulevard du Souvenir overpass	Canada	28 June 2000	Steel beams and concrete	1 Killed, 2 Injured
Hintze Ribeiro Bridge	Portugal	4 March 2001	Steel bridge built in 1887	59 killed
Laajasalo pedestrian bridge	Finland	22 November 2010	Steel reinforced concrete	1 killed
Severn Railway Bridge	England	25 October 1960	Cast Iron	5 Killed
Bull bridge	England	26 September 1860	Cast Iron Rail Bridge	Nil
Ashtabula River Railboard bridge	United states	29 December 1876	Wrought iron truss bridge	92 killed, 64 injured

Q 6.1 Using the data in the task, **discuss** and **evaluate** the impact of major bridge collapse across the globe. In your answer you should include:

D 12

- The impacts on the environment
- A social impact
- Few suggestions of how you would improve the quality of metal to improve it from collapsing
- A concluding appraisal of all of the issues you have discussed

Teacher's Explanation

<ul style="list-style-type: none"> <li>• Briefly mentioned the impact on the environment</li> <li>• A comment about the impact on the environment for eg. – wastage of metals and pollution of rivers and sea</li> </ul>	2 – 4
<ul style="list-style-type: none"> <li>• Briefly mentioned the impact on the environment</li> <li>• A comment about the social impact on the community for eg. – lots of people die due to collision</li> </ul>	4 – 6
<ul style="list-style-type: none"> <li>• Account of more than one impact on the environment</li> <li>• Account of more than one impact on the community</li> <li>• Account of suggestions to improve the quality of metal</li> <li>• Detailed list of comparison for eg. – painting the metal timely / using alloy</li> </ul>	6 – 8
<ul style="list-style-type: none"> <li>• Account of more than one impact on the environment</li> <li>• Account of more than one impact on the community</li> <li>• Account of suggestions to improve the quality of metal</li> <li>• Detailed list of comparison for eg. – painting the metal timely / using alloy</li> <li>• A concluding appraisal linking all the issues discussed above</li> </ul>	8 - 12



Oakridge International School

## MYP 4&5 Chemistry - 10 - copy

### IB Middle Years Chemistry

Grade: Grade 10

Criteria:  A 24  B 33  C 17  D 26

Total: 100 points

Authors: Punitha Neelamegam

## Question 1

### Knowing and understanding

This task (questions 1 and 2) addresses the key concept of **systems** and focuses on **criterion A** (Knowing and understanding).

Acids have a wide-ranging applications in industries, including manufacturing, cleaning, food preservation, and chemical synthesis.

Natural acids like citric acid and vinegar are used to lower pH levels in foods, inhibiting microbial growth and extending shelf life.

- Q 1.1 Acetic acid is used as a preservative in many food items. **State** the IUPAC name for the acetic acid and the functional group.

A 2

### Teacher's Explanation

IUPAC Name: Ethanoic acid

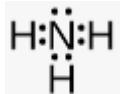
Functional group present: Carboxylic acid

Ammonia is a compound of nitrogen and hydrogen. It is a colourless gas with a characteristic pungent smell. In human health, ammonia and the ammonium ion are vital components of metabolic processes.

Q 1.2 Draw the Lewis structure of Ammonia.

A 1

Teacher's Explanation



Q 1.3

A 2

Find the missing terms and complete the following statement.

Ammonia is a base because it can accept a proton.

Teacher's Explanation

Ammonia is a base because it can accept a proton.

The Bronsted-Lowry theory defines an acid as a substance that donates a proton ( $H^+$ ) to another substance. Conversely, a base is defined as a substance that accepts a proton.

**Q 1.4** **Compare** and **contrast** the strengths of strong acids and strong bases in terms of their ability to donate or accept protons.

A 2

#### Teacher's Explanation

Strong acids are highly dissociated in water, meaning that they donate or transfer a high number of protons to water molecules.

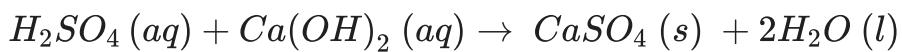
Strong bases are highly dissociated in water, meaning that they readily accept protons from water molecules.

The reaction of an acid with a base is called a neutralization reaction. The products of this reaction are a salt and water.

**Q 1.5** **Write down** the chemical equation for the reaction between sulphuric acid and calcium hydroxide along with its state symbols.

A 2

#### Teacher's Explanation



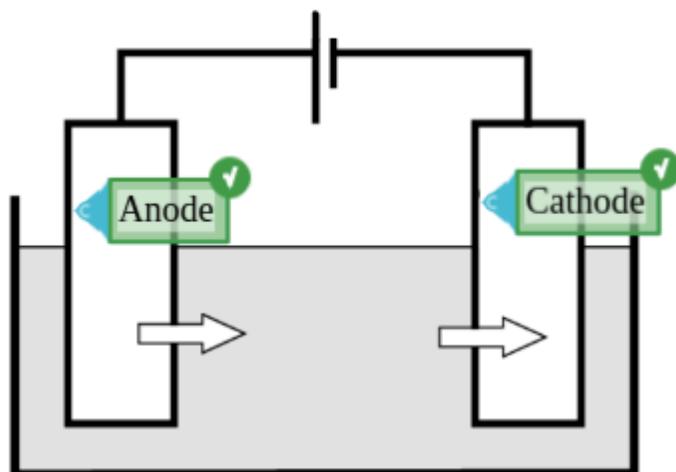
## Question 2

In electrolysis, electricity is used to trigger chemical changes, pivotal in metal plating, water purification, and more.

Electrolysis is a process which is widely used in the process of electroplating as well as in the production of hydrogen gas. It is also used in the industrial refining of various metals.

Q 2.1 Based on your understanding of the process of electrolytic system, **identify** the anode and cathode in an electrolytic cell.

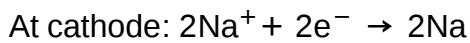
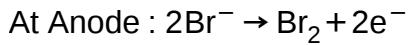
A 2



**Q 2.2** A student carried out the electrolysis of molten sodium bromide. **Write down** the half reaction for both anode and cathode.

A 2

Teacher's Explanation



**Q 2.3** **State** one observation that the student would notice at the anode electrode during the electrolysis of molten sodium bromide.

A 1

Teacher's Explanation

Red-brown/orangish color fumes at anode.

Batteries are composed of at least one electrochemical cell which is used for the storage and generation of electricity. Galvanic cell , which is a type of an electrochemical cell, converts chemical energy to electrical energy. Galvanic cells are the basic components of batteries, which are used to store and release electrical energy.

**Q 2.4** **Describe** the working of a electrochemical cell using an example.

A 2

Teacher's Explanation

Electrochemical cell is a device that converts chemical energy into electrical energy. It consists of two half cells each containing specific metal as electrode and the same metal salt solution as electrolyte. Redox reactions take place in both half cells in which Metal at anode lose electrons which are gained by metal ions at cathode. The transfer of electrons takes place through external wire connecting both

electrodes. Also salt bridge is used to connect both half cells and complete the circuit.

**Q 2.5** Based on your knowledge and understanding of an electrochemical cell, **explain why** salt bridge is used in a electrochemical setup.

A 4

#### Teacher's Explanation

- Maintains Electrical Neutrality: The salt bridge prevents buildup of charge at the electrodes, which would otherwise stop electron transfer and slow down the reaction. By allowing the flow of ions, the salt bridge maintains electrical neutrality and keeps the reaction going.
- Supplies Ions: The salt bridge provides a source of ions that can be transferred between the two half-cell compartments. This is important for maintaining the flow of electrons and for keeping the reaction going.

**Q 2.6** Given below are the combination of electrodes for the electrochemical cell. **Select** which combination will give maximum voltage output.

A 1

A Pb and Cu

B Fe and Mg

C Cu and Zn

D Al and Cu

## Question 3

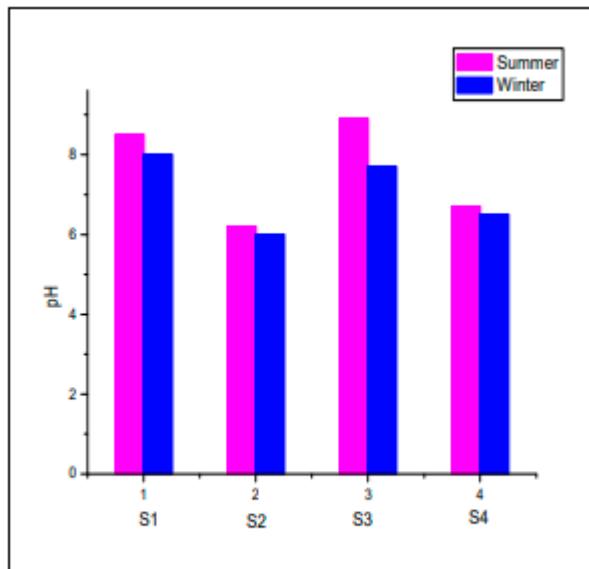
### Investigation skills

This task (questions 3 to 5) addresses the key concept of **relationships** and focuses on **criterion B** (Inquiring and designing) and **criterion C** (Processing and evaluating). In this task you will investigate how chemistry can be used to investigate about pH of different samples.

pH is the measurement scale indicating the acidity or alkalinity of a substance

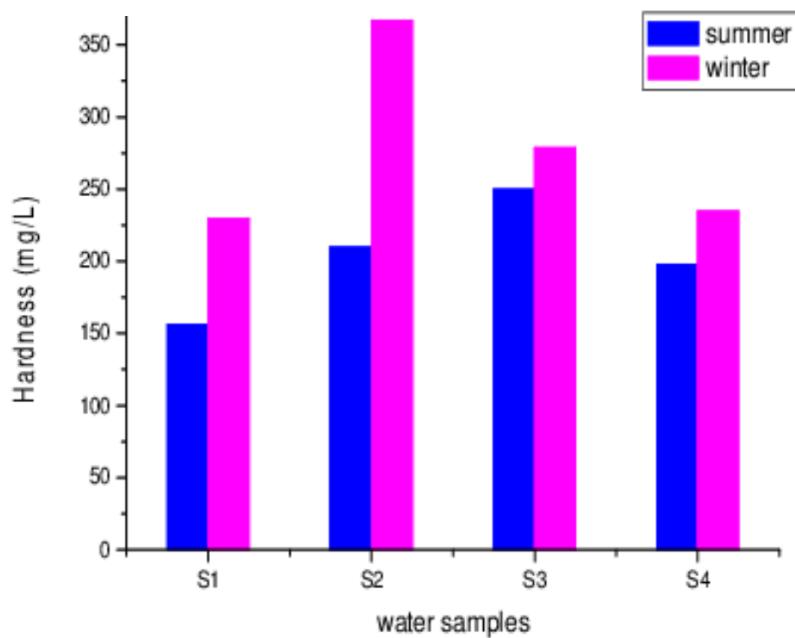
In chemistry, pH is a scale used to specify the acidity or basicity of an aqueous solution.

Content type: Image



**Fig. 2:** A plot showing pH variation of water Summer and Winter

pH variation of water in summer and winter



A plot showing Hardness of water in Summer and Winter

Hardness of water in summer and winter

**Q 3.1** **Formulate a research question based on the result obtained in the graph for pH sample.**

B 2

## Teacher's Explanation

How does the pH of water sample change according to the season?

- Q 3.2 Use the graphs to **construct** a data table for pH and hardness for different water samples in summer and winter.

C 3

## Teacher's Explanation

Sample	pH(Summer)	pH(Winter)	Hardness ( mg / L) (Summer)	Hardness ( mg / L) (Winter)
Area 1	8.5	8	156	230
Area 2	6.2	6	210	367
Area 3	8.9	7.7	250	279
Area 4	6.7	6.5	198	237

**Q 3.3** **Outline** the impact of change in pH level on the aquatic life.

D 2

#### Teacher's Explanation

Acidification: A decrease in pH levels can lead to acidification of water bodies, which can harm aquatic life by disrupting their biological processes, damaging their gills, and reducing their ability to reproduce.

Alkalinity: An increase in pH levels can also harm aquatic life by increasing the alkalinity of the water, which can reduce the availability of nutrients and dissolve heavy metals and other toxic substances that can be harmful to aquatic life.

**Q 3.4 U.S. Environmental Protection Agency (EPA) Drinking Water Quality**

C 2

**Standard:** pH value of drinking water should be 6.5 ~ 8.5.

**Suggest** the sample to be used as a water source for summer and winter.

#### Teacher's Explanation

Sample 4 during both summer and winter

**Q 3.5 Design** a method to investigate the pH of water in different areas around you. In your

B 13

answer, you should include –

- Independent, Dependent and two Control variable
- A list of equipment you will use
- The variables involved and how you will collect sufficient data
- Description of the method you will follow.

#### Teacher's Explanation

	1	2	3	4
<b>Variables</b>	IV and DV are correctly stated	IV and DV are outlined	IV, DV and one CV are outlined	IV, DV and 2 CVs are outlined correctly
<b>Requirement</b>	Relevant requirement required for <b>any one variable</b>	Relevant requirements required for <b>any two variables</b>	Relevant requirement required for <b>IV, DV and 2CVs</b>	
<b>Method</b>	<b>States</b> a method that allows for some data to be collected	method is <b>outlined</b> and could be followed by another student	method is <b>described</b> , includes fine detail and could be followed by another student	
<b>Sufficient data</b>	<b>more than one</b> sample are investigated <b>or</b> there is more than one trial	more than one samples are investigated <b>and</b> have mentioned 3 trials	5 values are investigated and 3 trials are mentioned along with calculating the mean.	

## Question 4

Nylon is a synthetic polymer material with diverse applications, used in textiles, plastics, and industrial products.

Nylon is a *polyamide* polymer characterized by the presence of *amide* groups—(CO-NH)—in the main polymer chain. A wide variety of nylon polymers are available but only two have found applications in tires: *nylon 6,6* and *nylon 6*.

Content type: Video

Video 4.1



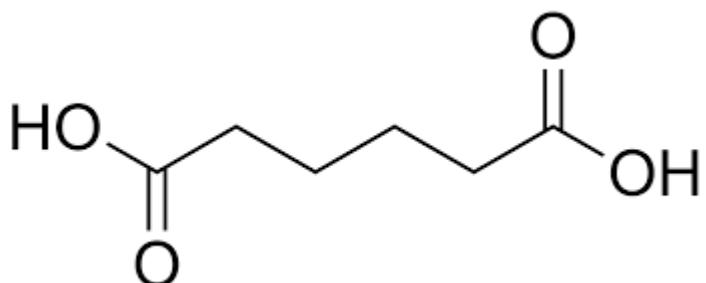
This item includes interactive content. Please refer to the digital version of this assessment to view this item.

Nylon 6,6 is prepared by the polymerization of hexamethylenediamine with adipic acid (Hexanedioic acid) under high pressure and at high temperature.

Q 4.1 Draw the structure of Adipic acid and state the functional group present in it.

A 2

Teacher's Explanation



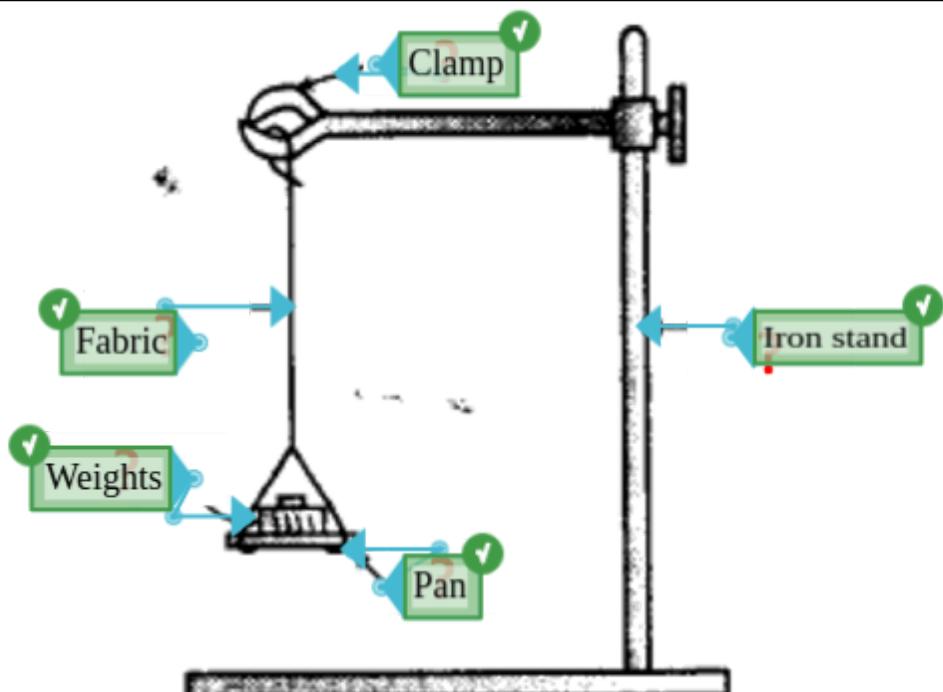
Functional group: Carboxylic acid

Tensile strength is a measurement of the force required to pull something such as rope, wire, or a structural beam to the point where it breaks.

Q 4.2 The strength of the different fabrics is determined by using the following equipment.

B 5

Label all the equipment used in the experiment.



Q 4.3 Using the equipment above, design a scientific method to determine the strength of different fibers such as cotton, wool, silk, polyester and nylon. In your answer you

B 13

should :

- Independent, Dependent and two Control variable
- A list of equipment you will use
- The variables involved and how you will collect sufficient data
- Description of the method you will follow.

### Teacher's Explanation

	1	2	3	4
Variables	IV and DV are correctly stated	IV and DV are outlined	IV, DV and one CV are outlined	IV, DV and 2 CVs are outlined correctly
Requirement	Relevant requirement required for <b>any one variable</b>	Relevant requirements required for <b>any two variables</b>	Relevant requirement required for <b>IV, DV and 2CVs</b>	
Method	<b>States</b> a method that allows for some data to be collected	method is <b>outlined</b> and could be followed by another student	method is <b>described</b> , includes fine detail and could be followed by another student	
Sufficient data	<b>more than one</b> sample are investigated <b>or</b> there is more than one trial	more than one samples are investigated <b>and</b> have mentioned 3 trials	5 values are investigated and 3 trials are mentioned along with calculating the mean.	

## Question 5

Material's capacity to withstand external forces without breaking, vital in industries like construction, aerospace, and manufacturing.

Marcus, a student decides to go trekking at the Alaska mountain range for which he decides to make rope for climbing and wants to check the strength of different fibers. He records the following observation -

Fiber	Total Weight required to break the Thread (Kg)
Cotton	1.5
Wool	0.5
Silk	2
Nylon	7
Polyester	4

Q 5.1 Using the given data, **organize** the fiber in the ascending order of their strength.

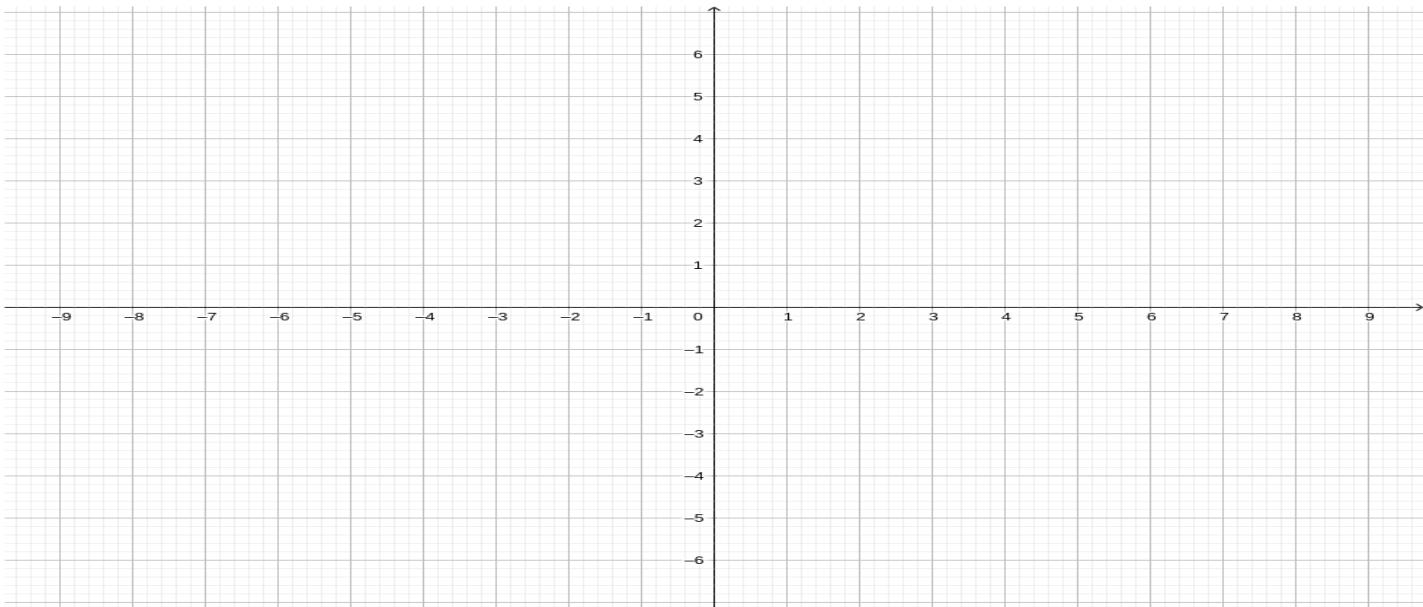
C 3

Teacher's Explanation

Wool < Cotton < Silk < Polyester < Nylon

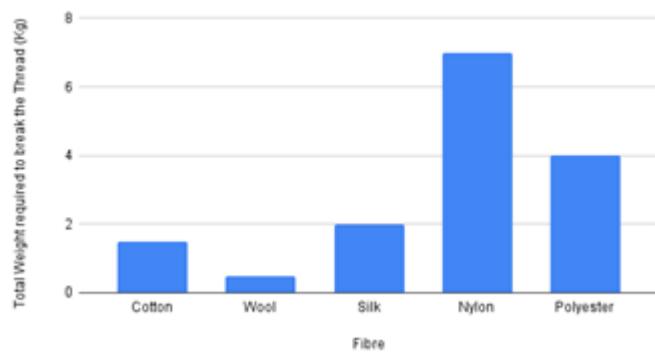
**Q 5.2** Present the data in appropriate graphical form. Label the graph with a suitable heading.

C 3



#### Teacher's Explanation

Total Weight required to break the Thread (Kg) vs. Fibre



**Q 5.3** Based on the data given in the table, identify the most appropriate fibre you would choose for climbing a mountain. Justify your answer.

C 2

#### Teacher's Explanation

Nylon: High tensile strength, won't break easily

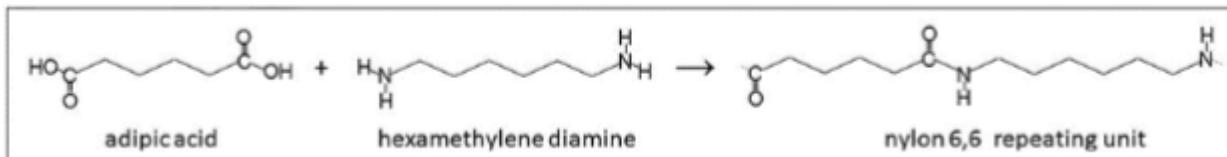
**Q 5.4** **State one improvement to this experiment that would increase the validity of this data.**

C 1

## Teacher's Explanation

Increase the number of trials and calculate average to eradicate errors

Given below is the branched-chain structure of nylon 6,6 which is a type of condensation polymer.



**Q 5.5** Define condensation polymer and looking at the structure. Identify the type of linkage bond in the polymer.

A 1

C 1

## Teacher's Explanation

Condensation polymer gives small molecules as a by product such as water molecule and small alcohol.

### Amide linkage

## Question 6

### Applying science

The global context is globalization and sustainability.

This task (questions 6 and 7) addresses the key concept of **change** and assesses **criterion D** (Reflecting on the impacts of science).

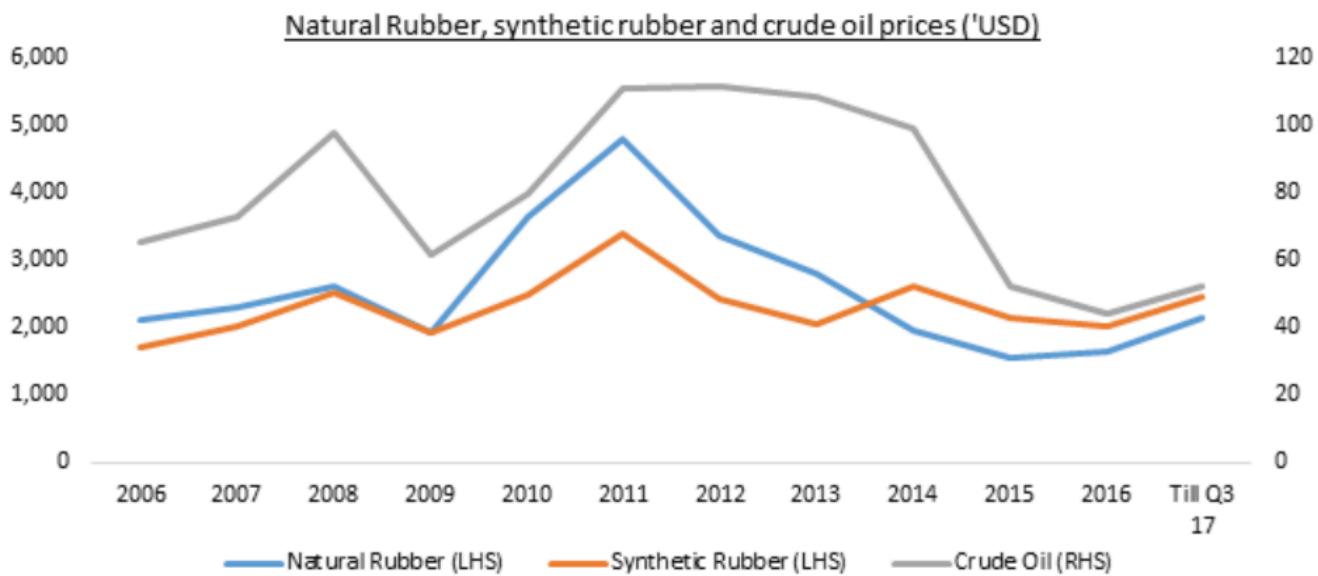
Plastic as a polymer has whole range of usage and being used for all sorts of packaging materials, bags, toys to name a few.

Neoprene or polychloroprene is a family of synthetic rubbers that are produced by the polymerization of chloroprene.

Neoprene exhibits good chemical stability and maintains flexibility over a wide temperature range. It has superior resistance to vegetable and mineral oils. It is used for manufacturing conveyor belts, gaskets, and hoses.

Natural rubber is natural polymer obtained from a plant. Synthetic rubber which is a type of polymer is also known as thermoplastic rubber is made from non-renewable resources, such as crude oil. The graph shows the relationship between the cost of natural rubber, synthetic rubber and crude oil from 2006 to 2017. The cost of each commodity fluctuated between 1000 USD to 6000 USD.

Content type: Image



Source: International Rubber Study Group and Bloomberg

Price trends

Q 6.1 Interpret the graph and identify the timeline when the cost of synthetic rubber surpassed the natural rubber.

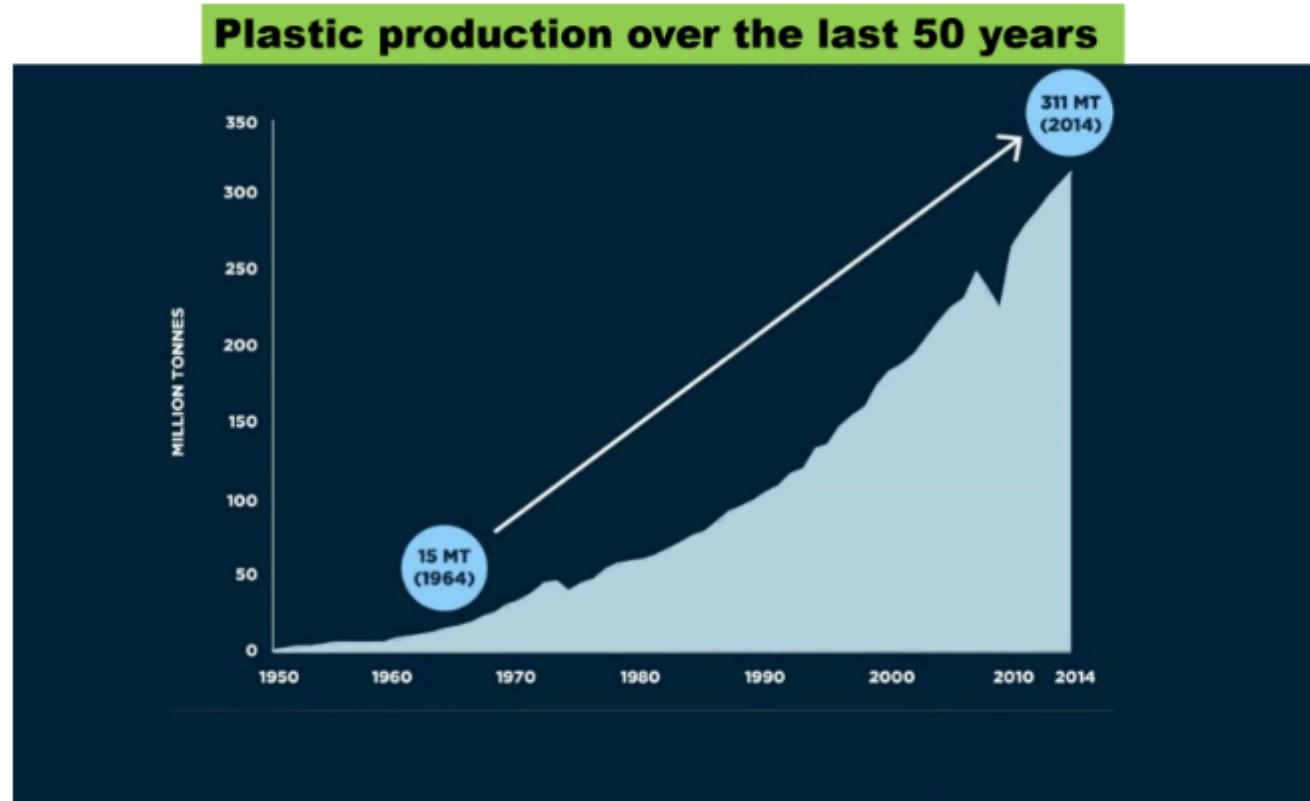
C 1

Teacher's Explanation

Between 2013 and 2014

Q 6.2 Using the graph below, **deduce** how many folds has plastic production increased over last 50 years.

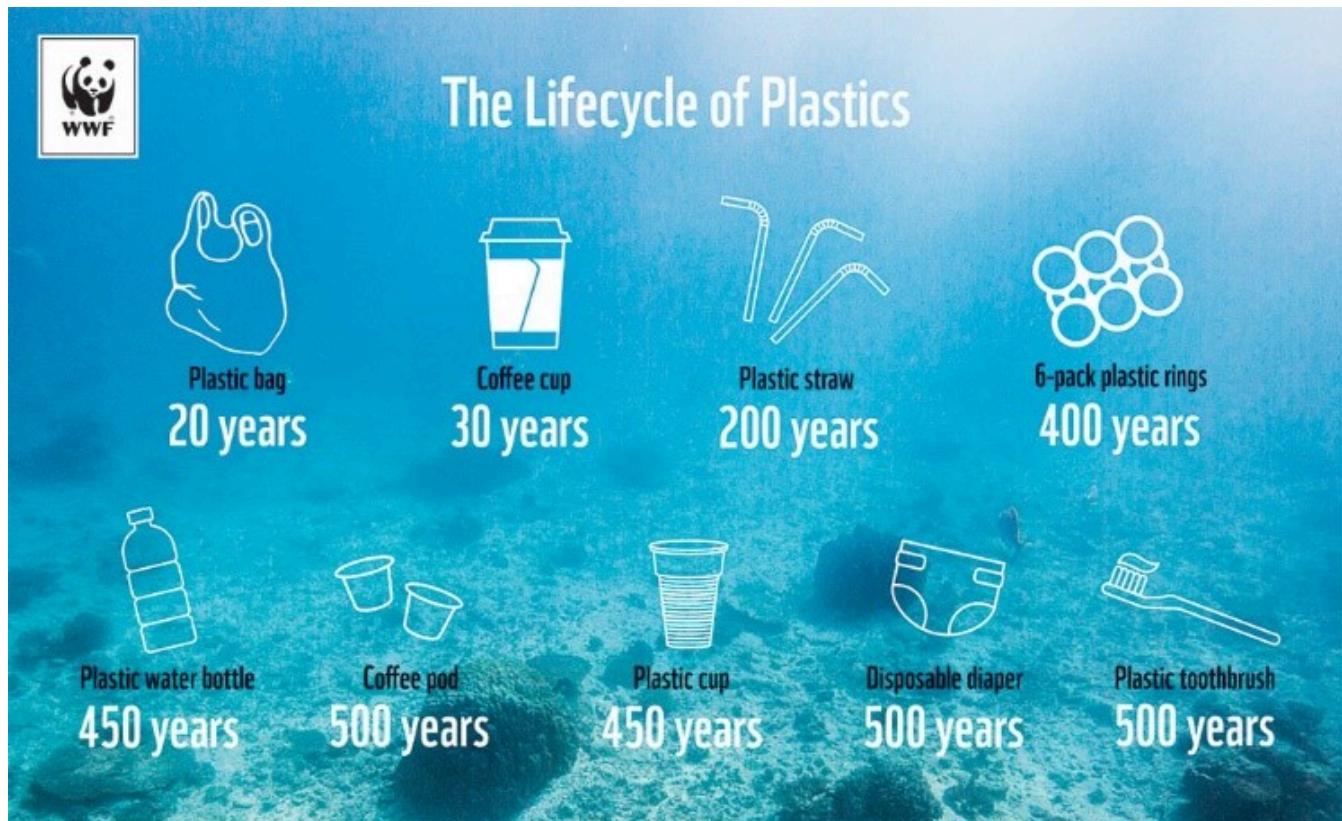
C 1



Teacher's Explanation

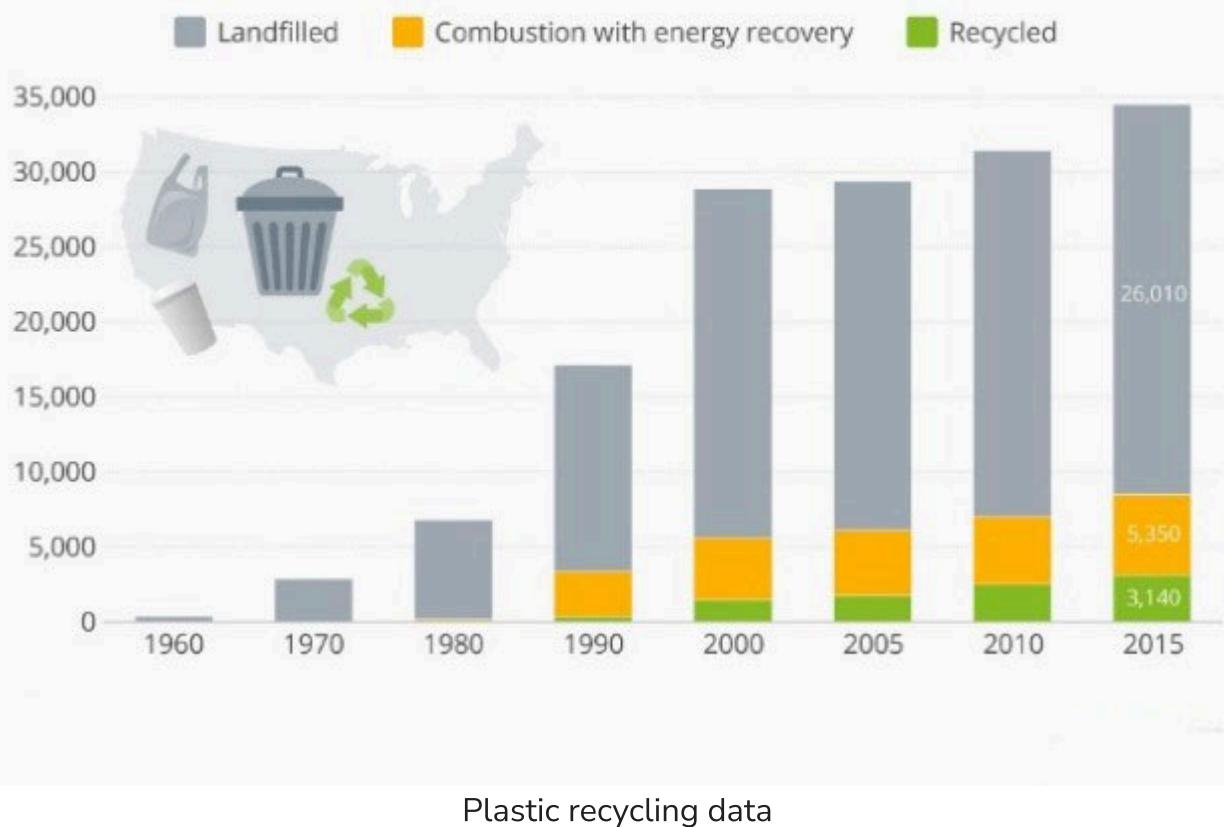
20 times or 20 folds

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## Plastic Recycling Still Has A Long Way To Go

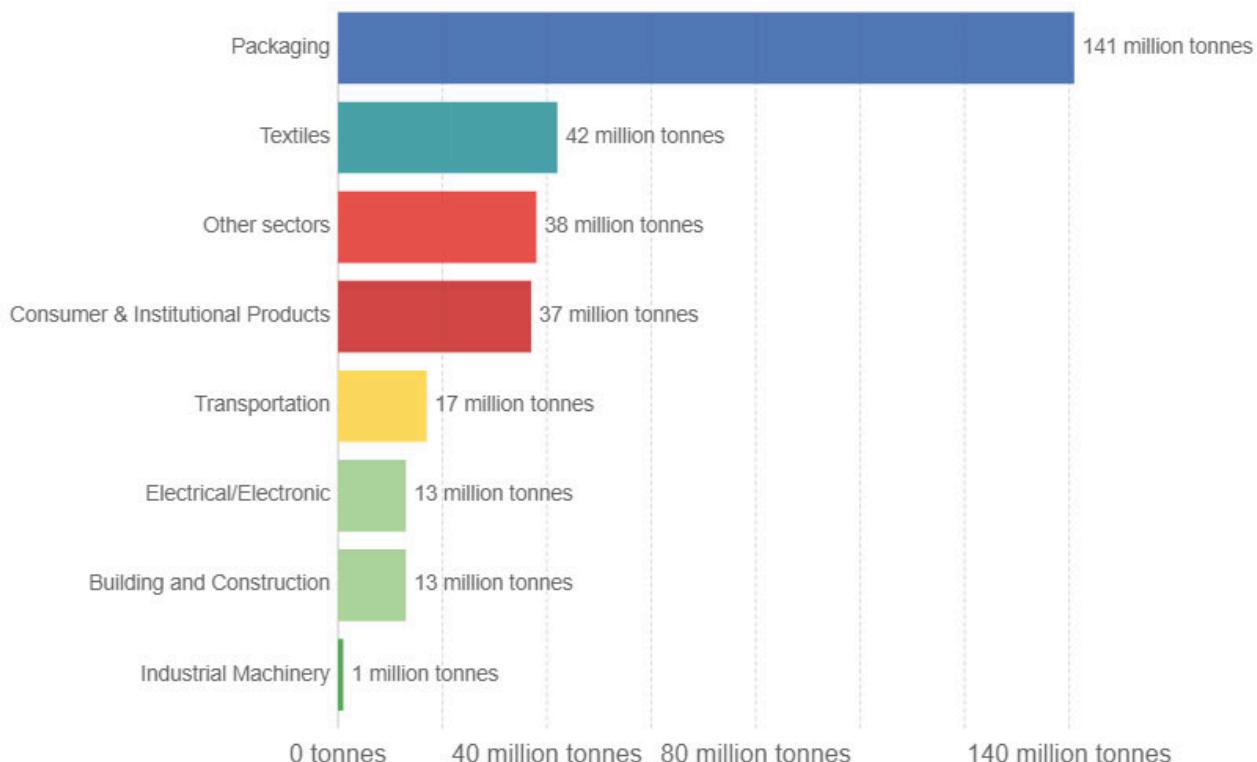
Level of plastic waste in U.S. municipal solid waste disposal (thousand tons)



Plastic recycling data

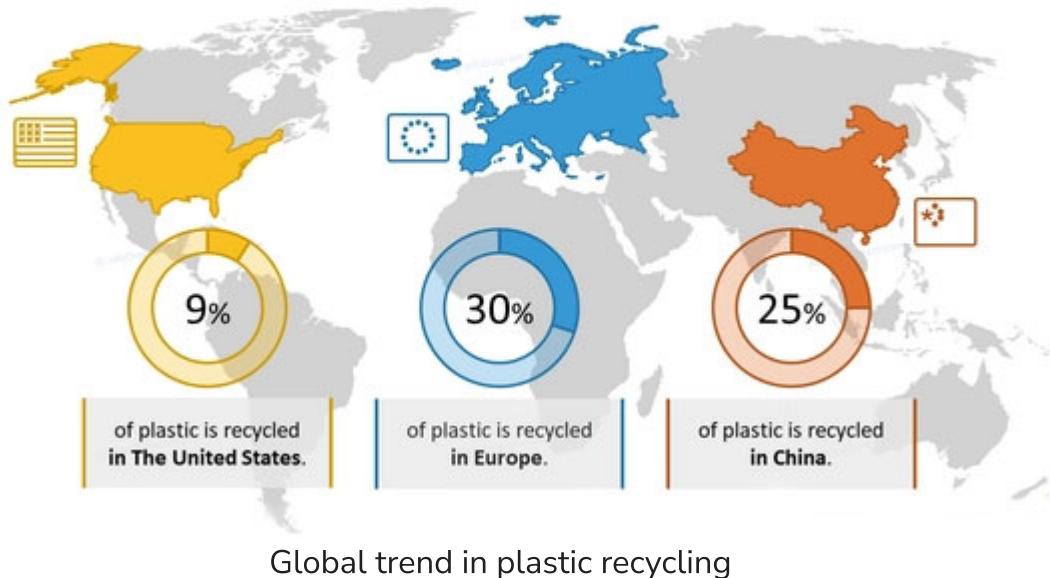
## Plastic waste generation by industrial sector, 2015

Global plastic waste generation by industrial sector, measured in tonnes per year.



Plastic waste generation data

Less than half of all plastic is recycled globally:



Q 6.3 Using the information from this task, **discuss** and **evaluate** how the use of plastic has shaped today's world. **Suggest** the alternative paths one could choose to reduce the use of plastics that could benefit the global community. In your answer you should include:

D 10

- Impacts of Using plastics on terrestrial and aquatic life
- Alternative method to deal with Plastics waste
- Advantages and Disadvantages of suggested alternate method
- Environmental and economical implication of suggested method
- A concluding appraisal of all of the issues you have discussed.

Teacher's Explanation

<ul style="list-style-type: none"> <li>• Relevant impact of using plastic related to terrestrial and aquatic life stated</li> <li>• Valid alternate method to deal with plastic waste</li> <li>• Advantages or disadvantage of method</li> <li>• Either an environmental or an economical implication is stated</li> </ul>	<b>1 - 4</b>
<ul style="list-style-type: none"> <li>• Relevant impact of using plastic related to terrestrial and aquatic life stated</li> <li>• Valid alternate method to deal with plastic waste</li> <li>• Advantage and disadvantage of suggested method</li> <li>• A statement of one environmental implication</li> <li>• A statement of one economical implication</li> </ul>	<b>5 - 6</b>
<ul style="list-style-type: none"> <li>• Relevant impacts (atleast 2) of using plastic related to terrestrial and aquatic life stated (2)</li> <li>• Valid alternate method to deal with plastic waste (1)</li> <li>• Advantage and disadvantage of suggested method (2)</li> <li>• A environmental implication with justification (2)</li> <li>• A statement of one economical implication with justification (2)</li> <li>• concluding appraisal (1)</li> </ul>	<b>7 - 10</b>

## Question 7

Environmental issue arising from the accumulation of discarded plastic waste in ecosystems is causing harm to wildlife and ecosystems.

Use of polymers such as polyethene and plastics makes our lives easier. Using plastic have a significant impact on the environment. Many countries around the world have started banning single use plastic.

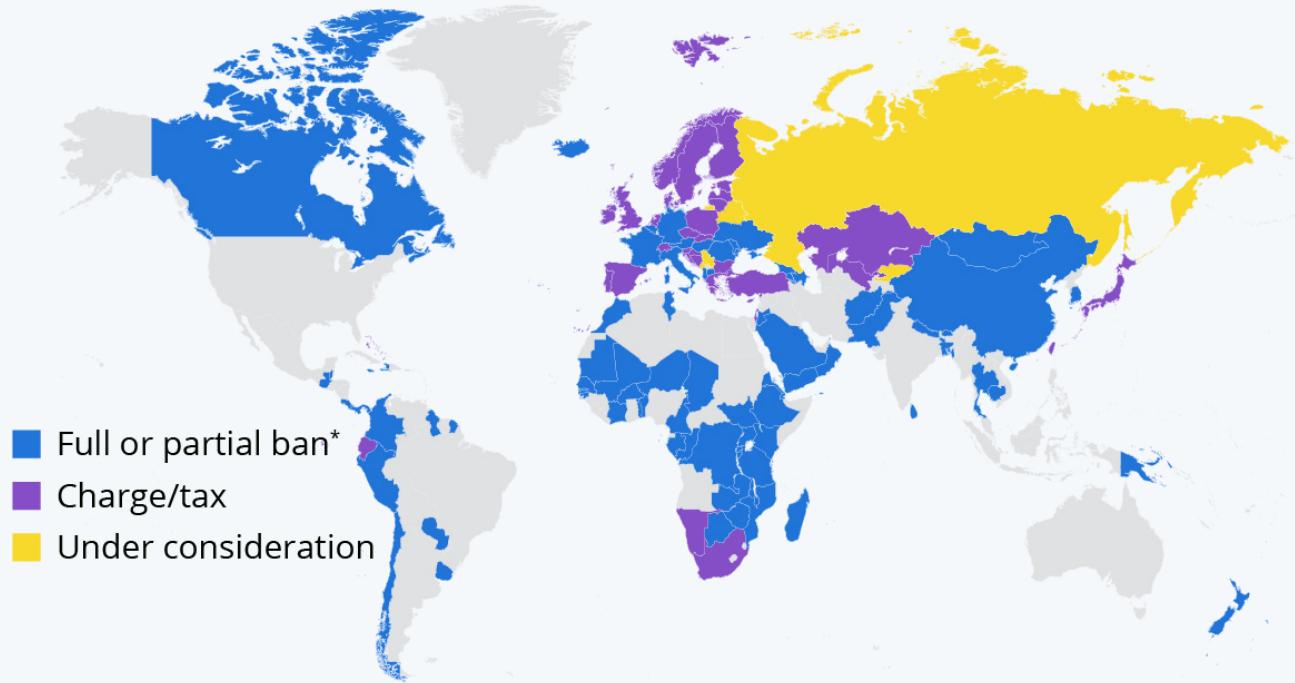
Content type: Image



Alternatives for plastic bags

# The Countries Banning Plastic Bags

National-level regulation to ban/limit the use of plastic bags (2021)



\* Can also include charges. Some bans not in effect yet

Sources: United Nations, media reports



**statista**

Countries banning plastic bags

# Washington State Bag Requirements

For Retailers, Grocers, Restaurants, and other Businesses



**NO**  
Single-use Plastic  
Carryout Bags



**8c charge**  
Large Paper  
Carryout Bags

Made with 40% recycled  
content. Charges must be  
retained by the business



**8c charge**  
Thick Reusable Plastic  
Carryout Bags

Made with 20% recycled  
content and a minimum of  
2.25 mil thick film. Charges must  
be retained by the business



**Charge optional**  
Compostable Carryout  
Bags Allowed but  
**Not Recommended**

Green or brown tinted film bags  
**must** be compostable.

Bag requirements

Q 7.1 **Discuss and evaluate** the Government's decision of banning use of single use plastic carry out bag and various types of bags suggested.

D 14

In your answer, you should include :

- Advantages of single use plastic bag and different category of bags
- Disadvantages of single use plastic bag and different category of bags
- The economic impact of government's decision
- The environmental impact of Ban on Single use plastic
- A concluding appraisal.

Teacher's Explanation

<ul style="list-style-type: none"> <li>• Advantages or disadvantage of any one type of bag</li> <li>• Either an economical or environmental impact is stated</li> </ul>	<b>1 - 2</b>
<ul style="list-style-type: none"> <li>• Advantage and disadvantage of plastic bags and other types of plastic</li> <li>• A statement of one economical impact of Govt. decision</li> <li>• A statement of one environmental impact of Ban on single use plastic</li> </ul>	<b>3 - 4</b>
<ul style="list-style-type: none"> <li>• Advantage and disadvantage of both method</li> <li>• A description of one economic impact of Govt. decision</li> <li>• A description of one environmental impact of Ban on single use plastic</li> </ul>	<b>5 - 8</b>
<ul style="list-style-type: none"> <li>• Advantage and disadvantage of both method (4)</li> <li>• A description of one economic impact of Govt. decision with justification (4)</li> <li>• A description of one environmental impact of Ban on single use plastic is justified (4)</li> <li>• A concluding appraisal (2)</li> </ul>	<b>9 - 14</b>

## Investigating the combustion of alcohols

Different fuels have different energy densities. The combustion of alcohol is an exothermic reaction in which water, carbon dioxide and heat energy are produced. You can compare the energy density of alcohols by using the subsequent heat produced to heat water.

6. Formulate a hypothesis for the relationship between the energy density of alcohols and the length of their carbon chain. Explain this using scientific reasoning. [3]
7. Design an experiment to test your hypothesis using some or all of the materials listed. You should include:
  - a) the method; include a drawing of your apparatus
  - b) the dependent, independent and control variables
  - c) any safety precautions required
  - d) a table for recording and analyzing results. [10]

### Equipment

- The following alcohols:
  - methanol ( $\text{CH}_3\text{OH}$ )
  - ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ )
  - propan-1-ol ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ )
  - butan-1-ol ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ )
- Spirit burner
- Electronic balance
- Aluminium drinks can
- Thermometer or temperature probe
- Clamp stand and clamp
- 100 cm<sup>3</sup> measuring cylinder
- Distilled water

## Investigating acid rain

Sulfur dioxide,  $\text{SO}_2$ , is emitted into the atmosphere both naturally (volcanoes) and as a consequence of human activities (combustion of fossil fuels). The mixing of this toxic gas with water is the cause of acid deposition.

6. Design a way of simulating acid rain formation by sulfur pollutants and investigate the effects of this pollutant on the pH of water. You could use the following points for guidance. [10]

### Equipment

- sulfur powder
- sodium hydrogencarbonate
- universal indicator solution
- a deflagration spoon
- bunsen burner
- gas jar
- distilled water.

Your design should include:

- how you will generate the sulfur dioxide gas
- the method used to enable the sulfur dioxide to dissolve in the distilled water
- how you will test to see if there has been a change in the pH of the solution
- details of the variables being kept constant during the experiment
- details of the safety issues and how you will minimize any risks.

7. Propose a research question for your investigation. [2]
8. Formulate a testable hypothesis and explain it using scientific reasoning. [4]



## Modelling global warming

Global warming can be defined as the actual and predicted increases in temperature of the Earth's atmosphere and oceans. The predictions are based on many types of evidence collected around the world by the scientific community.

Consider how you could use the following equipment to model global warming and the effect of the increasing amount of greenhouse gases in the atmosphere:

- three digital temperature probes/software or three glass thermometers
- three 1.5 litre soda bottles

56

- rubber bungs with a hole for the temperature probes/thermometers
- distilled water
- antacid tablets (when these are dissolved in water they produce carbon dioxide)
- high-capacity heat lamp
- 1 m ruler
- stopwatch.

**6.** Formulate a testable hypothesis. [3]

**7.** Design an experiment to test your hypothesis. The method should include:

- the independent and dependent variables, and other variables being controlled
- how you plan to record your quantitative and qualitative observations. [10]

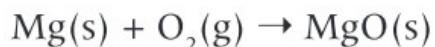
Calculate the number of moles in each of the following masses:

- a)** 9.8 g of sulfuric acid,  $\text{H}_2\text{SO}_4$
- b)** 25.0 g of calcium carbonate,  $\text{CaCO}_3$
- c)** 8.0 g of sodium hydroxide,  $\text{NaOH}$
- d)** 60 g of glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$

Calculate the mass (in grams) in each of the following:

- a)** 0.25 mol of carbon dioxide,  $\text{CO}_2$
- b)** 3 mol of ammonia,  $\text{NH}_3$
- c)** 0.710 mol of calcium phosphate,  $\text{Ca}_3(\text{PO}_4)_2$
- d)** 0.211 mol of iron(III) oxide,  $\text{Fe}_2\text{O}_3$

Magnesium burns in the presence of oxygen to form the metal oxide, magnesium oxide. This oxidation reaction is commonly performed in a school laboratory. A student weights out 18.0 g of magnesium for the reaction. The equation for the reaction is as follows:

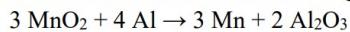


- a)** Balance the chemical equation.
- b)** Calculate the number of moles of the reactant, magnesium.
- c)** If oxygen is in excess and all the magnesium is used up, calculate the number of moles of magnesium oxide formed.
- d)** What mass of magnesium oxide is produced?

What mass of barium sulfate would be produced when 10 g of barium chloride is completely consumed in the following reaction?



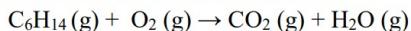
1. Manganese (IV) oxide reacts with aluminum to form elemental manganese and aluminum oxide:



What mass of Al is required to completely react with 25.0 g MnO<sub>2</sub>?

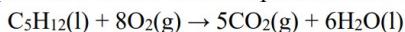
- a) 7.76 g Al
- b) 5.82 g Al
- c) 33.3 g Al
- d) 10.3 g Al

2. Consider the unbalanced equation for the combustion of hexane:



Balance the equation and determine how many moles of O<sub>2</sub> are required to react completely with 7.2 moles of C<sub>6</sub>H<sub>14</sub>.

3. How many moles of CO<sub>2</sub> are produced when 3 moles of pentane react with excess oxygen



- a) 5 moles
- b) 3/5 moles
- c) 15 moles
- d) 3 moles

4. The overall equation involved in photosynthesis is      6 CO<sub>2</sub> + 6 H<sub>2</sub>O → C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> + 6 O<sub>2</sub>.

How many grams of glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, 180.1 g/mol) form when 4.40 g of CO<sub>2</sub> react?

- a) 18.0 g
- b) 3.00 g
- c) 108 g
- d) 0.0167 g



# CIE IGCSE Chemistry



Your notes

## Redox

### Contents

- \* Oxidation & Reduction
- \* Redox & Electron Transfer



Your notes

## Oxidation & Reduction

### Oxidation & reduction

#### Roman numerals and oxidation numbers

- Transition elements can bond in different ways by forming ions with different charges
- When naming, the charge on the ion is shown by using a Roman numeral after the element's name
- For example, iron can form different ions
  - Iron ions with a 2+ charge,  $\text{Fe}^{2+}$ , are called **iron(II)** ions
  - Iron ions with a 3+ charge,  $\text{Fe}^{3+}$ , are called **iron(III)** ions
- The Roman numeral is the **oxidation number** of the element
- For example, iron reacts with oxygen to form iron oxide
  - But the name and formula of the product depend on the oxidation state of the iron ions
  - Iron(II) ions
    - The iron oxide product contains iron(II) ions,  $\text{Fe}^{2+}$
    - The name of this product is iron(II) oxide
    - The formula of this product is  $\text{FeO}$
  - Iron(III) ions
    - The iron oxide product contains iron(III) ions,  $\text{Fe}^{3+}$
    - The name of this product is iron(III) oxide
    - The formula of this product is  $\text{Fe}_2\text{O}_3$

#### Worked example

1. State the oxidation number of the transition metal ion in silver(I) chloride,  $\text{AgCl}$ .
2. Name, including Roman numeral, the compound with the formula  $\text{CoCl}_2$ .

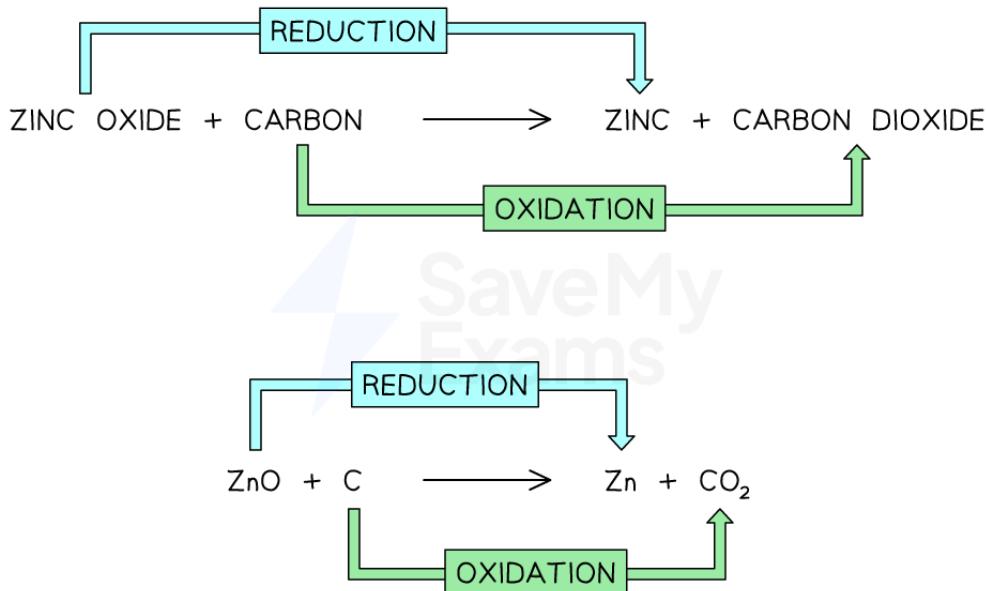
#### Answers:

1. The oxidation number of the transition metal ion in silver(I) chloride,  $\text{AgCl}$ , is 1
  - **Remember:** The Roman numeral gives the oxidation number of the element before
2. The name, including Roman numeral, of the chemical with the formula  $\text{CoCl}_2$  is cobalt(II) chloride
  - $\text{CoCl}_2$  contains two chloride ions, each with a 1– charge
  - So, the cobalt ion has a 2+ charge
  - This means the compound contains cobalt(II) ions,  $\text{Co}^{2+}$
  - Therefore, it is called cobalt(II) chloride

### What is a redox reaction?

- A **redox** reaction is where oxidation and reduction take place together at the same time in the same reaction
- In terms of oxygen:
  - **Oxidation** is where **oxygen** is **added** to an element or a compound
  - **Reduction** is where **oxygen** is **removed** from an element or compound

- The reaction between zinc oxide and carbon is an example of a redox reaction
  - Zinc oxide is reduced because it has **lost** oxygen
  - Carbon is oxidised because it has **gained** oxygen



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**Both reduction and oxidation has occurred in this reaction so it is classed as a redox reaction**



Your notes

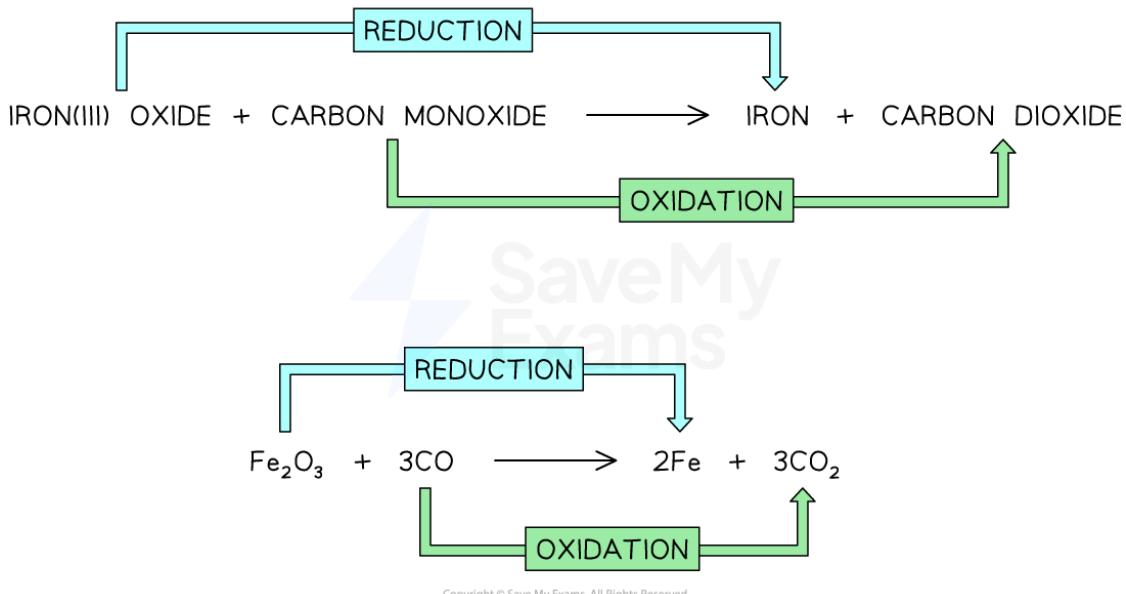
## Worked example

Explain which chemicals that are reduced and oxidised in the reaction between iron(III) oxide and carbon.



**Answer:**

- Iron(III) oxide loses oxygen, so it is reduced
- Carbon monoxide gains oxygen, so it is oxidised



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## Exam Tip

You may see the term oxidation state used instead of oxidation number.

Although there is a subtle difference between the two terms (this is beyond the scope of this course), they are often used interchangeably.

Usually oxidation number is used to refer to the Roman numerals found within the name.



Your notes

## Redox & Electron Transfer

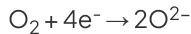
### Redox & electron transfer

Extended tier only

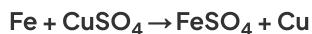
- Redox reactions can also be defined in terms of electron transfer
- **Oxidation** is a reaction in which an element, ion or compound **loses electrons**
  - The **oxidation number** of the element is **increased**
  - This can be shown in a half-equation, e.g. when silver reacts with chlorine, silver is **oxidised** to silver ions:



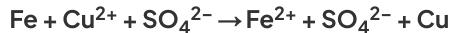
- **Reduction** is a reaction in which an element, ion or compound **gains electrons**
  - The **oxidation number** of the element is **decreased**
  - This can be shown in a half-equation, e.g. when oxygen reacts with magnesium, oxygen is **reduced** to oxide ions:



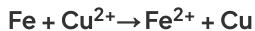
- For example, when iron reacts with a compound of copper such as copper sulfate, a displacement reaction occurs



- We can write this as an **ionic equation**

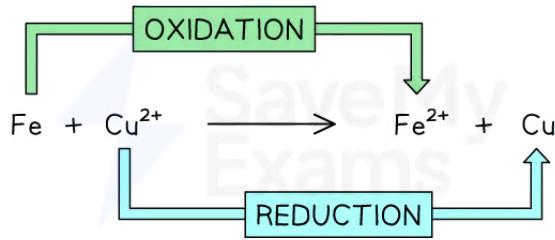


- We can then remove the spectator ions to see the overall change



- The iron atom has lost electrons to become a positive ion, so has been oxidised
- The positive copper ion has gained electrons to become an atom, so have been reduced

#### The redox reaction between Fe and Cu<sup>2+</sup>



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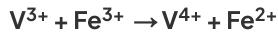
The Fe atom is oxidised (loses electrons) and the Cu<sup>2+</sup> ion is reduced (gains electrons)



Your notes

## Worked example

Which change in the following equation is oxidation?



**Answer:**

- **Step 1** - Identify the changes for each species:
  - $\text{V}^{3+}$  to  $\text{V}^{4+}$ 
    - $\text{V}^{3+}$  has lost 1 electron
  - $\text{Fe}^{3+}$  to  $\text{Fe}^{2+}$ 
    - $\text{Fe}^{3+}$  has gained 1 electron
- **Step 2** - Identify each change as either oxidation and reduction
  - $\text{V}^{3+}$  to  $\text{V}^{4+}$  is oxidation
  - $\text{Fe}^{3+}$  to  $\text{Fe}^{2+}$  is reduction
- Therefore,  $\text{V}^{3+}$  has been oxidised

## Exam Tip

Use the mnemonic **OIL-RIG** to remember oxidation and reduction in terms of the movement of electrons:

- **Oxidation Is Loss**
- **Reduction Is Gain.**

## Identifying redox reactions

Extended tier only



Your notes

### Identifying redox reactions using oxidation numbers

- The **oxidation number** is a number assigned to an atom or ion in a compound
- It shows the number of electrons that an atom has lost, gained or shared in forming a compound
  - So, the oxidation number helps you to keep track of the movement of electrons in a redox process
- It is written as a +/- sign followed by a number
  - Positive oxidation number = loss of electrons
  - Negative oxidation number = gain of electrons
  - For example, aluminium in a compound usually has the oxidation number of +3 indicating it has lost 3 electrons
  - **Careful:** It is easy to confuse oxidation number with charge which is written by a number followed by a +/- sign)
- A few simple rules help guide you through the process of determining the oxidation number of any element

### Rules for assigning oxidation numbers

	Rule	Example
1	The oxidation number of any uncombined element is zero	$H_2$ $Zn$ $O_2$
2	Many atoms or ions have fixed oxidation numbers in compounds	Group 1 elements are always +1 Group 2 elements are always +2 Fluorine is always -1 Hydrogen is +1, except in hydrides like $NaH$ where it is -1 Oxygen is -2, except in peroxides where it is in -1 and in $F_2O$ where it is +2
3	The oxidation number of an element in a monoatomic ion is always the same as the charge	$Zn^{2+} = +2$ $Fe^{3+} = +3$ $Cl^- = -1$
4	The sum of the oxidation numbers in a compound is zero	$NaCl$ $Na = +1$ $Cl = -1$ Sum of oxidation numbers = $1 - 1 = 0$
5	The sum of the oxidation numbers in an ion is equal to the charge on the ion	$SO_4^{2-}$ $S = +6$ Four O atoms = $4 \times (-2) = -8$ Sum of oxidation numbers = $6 - 8 = -2$

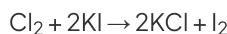
<b>6</b>	In either a compound or an ion, the more electronegative element is given the negative oxidation number	$\text{F}_2\text{O}$ Two F atoms = $2 \times (-1) = -2$ $\text{O} = +2$
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- Redox reactions can be identified by the changes in the **oxidation number** when a reactant goes to a product

### Worked example

The equation for the reaction between chlorine and potassium iodide is shown below.



Identify which species has been:

- a. Oxidised
- b. Reduced

**Answer:**

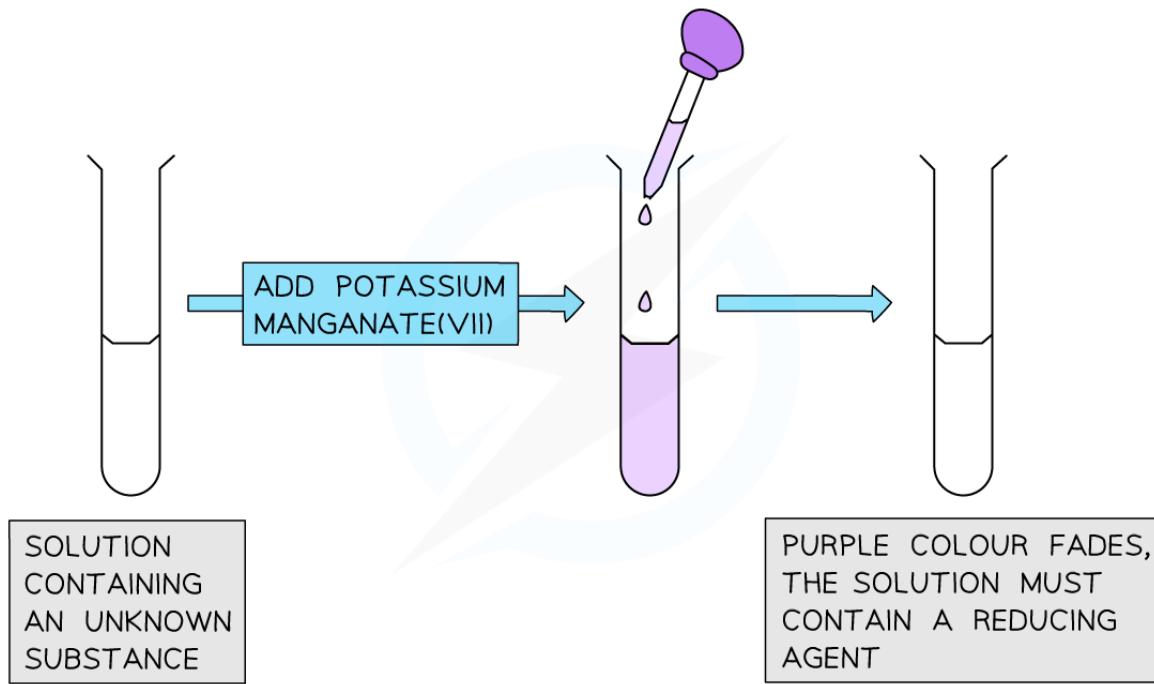
- a. The species that has been oxidised is iodine
  - $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$
  - The oxidation number of  $\text{I}^-$  is  $-1$
  - The oxidation number of iodine in  $\text{I}_2$  is  $0$
  - The oxidation number has increased so the iodide ions have been oxidised / lost electrons
- b. The species that has been reduced is chloride ions
  - $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$
  - The oxidation number of chlorine as  $\text{Cl}_2$  is  $0$
  - The oxidation number of  $\text{Cl}^-$  is  $-1$
  - The oxidation number has decreased so the  $\text{Cl}_2$  has been reduced / gained electrons

### Identifying redox reactions by colour changes

- The tests for redox reactions involve the observation of a colour change in the solution being analysed
- Two common examples are acidified potassium manganate(VII), and potassium iodide
- Potassium manganate(VII),  $\text{KMnO}_4$ , is an **oxidising agent** which is often used to test for the presence of **reducing agents**
- When acidified potassium manganate(VII) is added to a reducing agent its colour changes from **purple** to **colourless**



Your notes



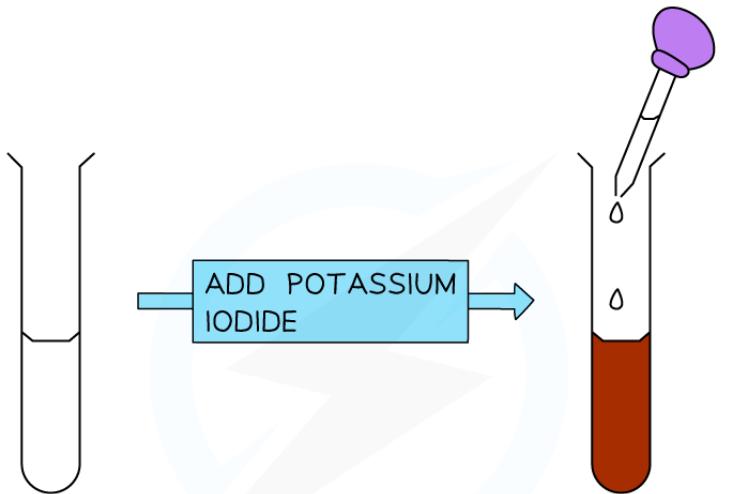
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**Diagram to show the colour change when potassium manganate(VII) is added to a reducing agent**

- Potassium iodide, KI, is a **reducing** agent which is often used to test for the presence of **oxidising** agents
- When added to an acidified solution of an oxidising agent such as aqueous chlorine or hydrogen peroxide ( $H_2O_2$ ), the solution turns a **red-brown** colour due to the formation of iodine,  $I_2$



Your notes



SOLUTION OF ACIDIFIED HYDROGEN PEROXIDE  
(AN OXIDISING AGENT)

THE SOLUTION TURNS RED-BROWN AS POTASSIUM IODIDE IS OXIDISED BY THE OXIDISING AGENT AND IODINE IS FORMED

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**Diagram to show the colour change when potassium iodide is added to an oxidising agent**

- The potassium iodide is oxidised as it loses electrons
- The hydrogen peroxide is reduced
- Therefore, potassium iodide is acting as a **reducing agent**

## Oxidising & reducing agents

Extended tier only



Your notes

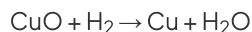
### What is an oxidising agent?

- An oxidising agent is a substance that **oxidises** another substance, and becomes **reduced** in the process
- An oxidising agent **gains** electrons as another substance loses electrons
- Common examples include hydrogen peroxide, fluorine and chlorine

### What is a reducing agent?

- A reducing agent is a substance that **reduces** another substance, and becomes **oxidised** in the process
- A reducing agent **loses** electrons as another substance gains electrons
- Common examples include carbon and hydrogen
- The process of reduction is very important in the chemical industry as a means of extracting metals from their ores

### Identifying oxidising and reducing agents



- Hydrogen is reducing the CuO
- Hydrogen is itself oxidised as it has gained oxygen / lost electrons
- So, the **reducing agent is hydrogen**:

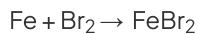


- CuO is reduced by hydrogen
  - This means that the hydrogen is oxidised by CuO
- CuO is reduced as it has lost oxygen / gained electrons
- So, the **oxidising agent is copper oxide**



## Worked example

When iron reacts with bromine to form iron(II) bromide, a redox reaction occurs:



Which species is acting as the reducing agent in this reaction?

### Answer

**1. Step 1** - Write half equations to work out what has gained/lost electrons

- $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
- $\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-$
- Fe loses electrons; Br<sub>2</sub> gains electrons

**2. Step 2** - Deduce what has been oxidised/reduced (remember OIL RIG)

- Fe has been oxidised as it has lost electrons
- Br<sub>2</sub> has been reduced as it has gained electrons

**3. Step 3** - Identify the reducing agent

- Fe is the reducing agent as it has been oxidised by losing electrons and caused Br<sub>2</sub> to be reduced as it gained electrons



Your notes

## Stoichiometry - Limiting Reactants

1. Hydrogen gas can be produced in the laboratory by the reaction of magnesium metal with hydrochloric acid.
- How many grams of hydrogen can be produced when 4.00 g of hydrochloric acid are added to 3.00 g of magnesium?

$$\left( \frac{4.00 \text{ g HCl}}{36.461 \text{ g/mol}} \right) \left( \frac{1 \text{ mol H}_2}{2 \text{ mol HCl}} \right) \left( 2.01588 \frac{\text{g}}{\text{mol}} \right) = 0.111 \text{ g H}_2$$

$$\left( \frac{3.00 \text{ g Mg}}{24.305 \text{ g/mol}} \right) \left( \frac{1 \text{ mol H}_2}{1 \text{ mol Mg}} \right) \left( 2.01588 \frac{\text{g}}{\text{mol}} \right) = 0.249 \text{ g H}_2$$

$\therefore \boxed{0.111 \text{ g H}_2 \text{ produced}}$

- What is the volume of this hydrogen at standard conditions?

$$\left( \frac{0.111 \text{ g H}_2}{2.01588 \text{ g/mol}} \right) \left( 22.4 \frac{\text{L}}{\text{mol}} \right) = \boxed{1.23 \text{ L H}_2}$$

2. Potassium nitrate is widely used as a fertilizer because it provides two essential elements, potassium and nitrogen. It is made by mixing potassium chloride and nitric acid in the presence of oxygen according to the equation:



How many kilograms of potassium nitrate will be produced from 50.0 kg of potassium chloride and 50.0 kg of nitric acid? An important by-product is chlorine. How many kilograms of chlorine will be produced?

$$\left( \frac{50000 \text{ g KCl}}{74.5513 \text{ g/mol}} \right) \left( \frac{4 \text{ mol KNO}_3}{4 \text{ mol KCl}} \right) \left( 101.1032 \frac{\text{g}}{\text{mol}} \right) = 67800 \text{ g}$$

KCl is  
the limiting  
reactant

$$\left( \frac{50000 \text{ g HNO}_3}{63.013 \text{ g/mol}} \right) \left( \frac{4 \text{ mol KNO}_3}{4 \text{ mol HNO}_3} \right) \left( 101.1032 \frac{\text{g}}{\text{mol}} \right) = 80200 \text{ g}$$

$\therefore \boxed{67.8 \text{ kg KNO}_3 \text{ produced}}$

$$\left( \frac{50000 \text{ g KCl}}{74.5513 \text{ g/mol}} \right) \left( \frac{2 \text{ mol Cl}_2}{4 \text{ mol KCl}} \right) \left( 70.906 \frac{\text{g}}{\text{mol}} \right) = 23.800 \text{ g} \quad \therefore \boxed{23.8 \text{ kg Cl}_2 \text{ produced}}$$

3. Phosphorus forms a compound similar to ammonia. The compound has the formula  $\text{PH}_3$  and is called phosphine. It can be prepared by the reaction:



If 20.0 g of phosphorus and 50.0 g of sodium hydroxide are reacted with excess water, how many grams of phosphine will be obtained?

$$\left( \frac{20.0 \text{ g P}_4}{123.895 \text{ g/mol}} \right) \left( \frac{1 \text{ mol PH}_3}{1 \text{ mol P}_4} \right) \left( 33.9976 \frac{\text{g}}{\text{mol}} \right) = 5.49 \text{ g}$$

$$\left( \frac{50.0 \text{ g NaOH}}{39.99711 \text{ g/mol}} \right) \left( \frac{1 \text{ mol PH}_3}{3 \text{ mol NaOH}} \right) \left( 33.9976 \frac{\text{g}}{\text{mol}} \right) = 14.2 \text{ g}$$

$\therefore \boxed{5.49 \text{ g PH}_3 \text{ produced}}$

4. Bromine can be prepared by adding chlorine to an aqueous solution of sodium bromide. How many grams of bromine are formed if 25.0 g of sodium bromide and 25.0 g of chlorine are reacted?

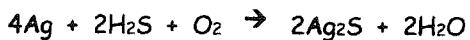


$$\left( \frac{25.0 \text{ g NaBr}}{102.89 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } Br_2}{2 \text{ mol NaBr}} \right) \left( 159.808 \frac{\text{g}}{\text{mol}} \right) = 19.4 \text{ g } Br_2$$

$$\left( \frac{25.0 \text{ g } Cl_2}{70.906 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } Br_2}{1 \text{ mol } Cl_2} \right) \left( 159.808 \frac{\text{g}}{\text{mol}} \right) = 56.3 \text{ g } Br_2$$

$\therefore \boxed{19.4 \text{ g } Br_2 \text{ produced.}}$

5. Silver tarnishes in the presence of hydrogen sulfide, a gas that originates from the decay of food, because of the reaction:



The black product, silver sulfide, is the "tarnish". If 25.00 g of silver, 5.00 g of hydrogen sulfide, and 4.00 g of oxygen are present in a reaction mixture, which one is the limiting reactant, and what mass of silver sulfide is produced?

$$\left( \frac{25.00 \text{ g Ag}}{107.8682 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } Ag_2S}{4 \text{ mol Ag}} \right) \left( 247.80 \frac{\text{g}}{\text{mol}} \right) = 28.72 \text{ g } Ag_2S$$

$$\left( \frac{5.00 \text{ g } H_2S}{34.082 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } Ag_2S}{2 \text{ mol } H_2S} \right) \left( 247.80 \frac{\text{g}}{\text{mol}} \right) = 36.4 \text{ g } Ag_2S$$

$$\left( \frac{4.00 \text{ g } O_2}{31.9988 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } Ag_2S}{2 \text{ mol } H_2S} \right) \left( 247.80 \frac{\text{g}}{\text{mol}} \right) = 62.0 \text{ g } Ag_2S$$

$\therefore \boxed{Ag \text{ is the limiting reactant and } 28.72 \text{ g } Ag_2S \text{ produced}}$

6. Sulfur dioxide can be produced from the reaction of hydrogen sulfide and oxygen as shown by the following reaction:  $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$

- a) How many grams of sulfur dioxide can be produced from 70.0 g of hydrogen sulfide and 125 g of oxygen.

$$\left( \frac{70.0 \text{ g } H_2S}{34.082 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } SO_2}{2 \text{ mol } H_2S} \right) \left( 64.065 \frac{\text{g}}{\text{mol}} \right) = 132 \text{ g } SO_2$$

$$\left( \frac{125 \text{ g } O_2}{31.9988 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } SO_2}{3 \text{ mol } O_2} \right) \left( 64.065 \frac{\text{g}}{\text{mol}} \right) = 167 \text{ g } SO_2$$

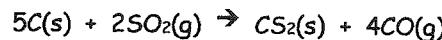
$\therefore \boxed{132 \text{ g } SO_2 \text{ produced}}$

- b) How many grams of excess reactant are left over after the reaction is complete?

$$\left( \frac{70.0 \text{ g } H_2S}{34.082 \text{ g/mol}} \right) \left( \frac{3 \text{ mol } O_2}{2 \text{ mol } H_2S} \right) \left( 31.9988 \frac{\text{g}}{\text{mol}} \right) = 98.6 \text{ g } O_2 \text{ needed}$$

$$125 \text{ g} - 98.6 \text{ g} = \boxed{26 \text{ g } O_2 \text{ left over}}$$

7. What mass of carbon disulfide is produced when 17.5 g of carbon are reacted with 39.5 g of sulfur dioxide according to the equation:



$$\left( \frac{17.5 \text{ g C}}{12.011 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } CS_2}{5 \text{ mol C}} \right) \left( \frac{76.143 \text{ g}}{\text{mol}} \right) = 22.2 \text{ g } CS_2$$

$$\left( \frac{39.5 \text{ g } SO_2}{64.0648 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } CS_2}{2 \text{ mol } SO_2} \right) \left( \frac{76.143 \text{ g}}{\text{mol}} \right) = 23.5 \text{ g } CS_2$$

$\therefore 22.2 \text{ g } CS_2 \text{ produced}$

8. What mass of P<sub>4</sub> is produced when 41.5 g of Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>, 26.5 g of SiO<sub>2</sub> and 7.80 g of C are reacted according to the equation:



$$\left( \frac{41.5 \text{ g } Ca_3(PO_4)_2}{310.17672 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } P_4}{2 \text{ mol } Ca_3(PO_4)_2} \right) \left( \frac{123.89504 \text{ g}}{\text{mol}} \right) = 8.29 \text{ g } P_4$$

$$\left( \frac{26.5 \text{ g } SiO_2}{60.0843 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } P_4}{6 \text{ mol } SiO_2} \right) \left( \frac{123.89504 \text{ g}}{\text{mol}} \right) = 9.11 \text{ g } P_4$$

$$\left( \frac{7.80 \text{ g C}}{12.011 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } P_4}{10 \text{ mol C}} \right) \left( \frac{123.89504 \text{ g}}{\text{mol}} \right) = 8.05 \text{ g } P_4$$

$\therefore 8.05 \text{ g } P_4 \text{ produced}$

9. What volume of carbon dioxide, measured at STP, can be produced when 15.65 g of pentane is reacted with 40.0 L of oxygen, measured at STP, according to the equation:



$$\left( \frac{15.65 \text{ g } C_5H_{12}}{72.15028 \text{ g/mol}} \right) \left( \frac{5 \text{ mol } CO_2}{1 \text{ mol } C_5H_{12}} \right) \left( 22.4 \frac{\text{L}}{\text{mol}} \right) = 24.3 \text{ L } CO_2$$

$$\left( \frac{40.0 \text{ L } O_2}{22.4 \text{ L/mol}} \right) \left( \frac{5 \text{ mol } CO_2}{8 \text{ mol } O_2} \right) \left( 22.4 \frac{\text{L}}{\text{mol}} \right) = 25.0 \text{ L } CO_2$$

$\therefore 24.3 \text{ L } CO_2 \text{ produced}$

10. What mass of hydrogen chloride gas is produced when 4.50 g of hydrogen and 140.0 g of chlorine are reacted. Which reactant is in excess and how much remains unreacted?



$$\left( \frac{4.50 \text{ g } H_2}{2.01588 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } HCl}{1 \text{ mol } H_2} \right) \left( 36.46094 \frac{\text{g}}{\text{mol}} \right) = 163 \text{ g } HCl$$

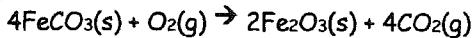
$$\left( \frac{140.0 \text{ g } Cl_2}{70.906 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } HCl}{1 \text{ mol } Cl_2} \right) \left( 36.46094 \frac{\text{g}}{\text{mol}} \right) = 144.0 \text{ g } HCl$$

$\therefore 144.0 \text{ g } HCl$  produced,  $H_2$  is in excess

$$\left( \frac{140.0 \text{ g } Cl_2}{70.906 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } H_2}{1 \text{ mol } Cl_2} \right) \left( 2.01588 \frac{\text{g}}{\text{mol}} \right) = 3.980 \text{ g } H_2 \text{ needed}$$

$$4.50 \text{ g} - \frac{3.980 \text{ g}}{\text{needed}} = \underline{0.52 \text{ g } H_2 \text{ remains unreacted}}$$

11. The roasting of siderite ore,  $FeCO_3$ , produces ferric oxide:



What mass of ferric oxide is produced when 55.0 g of siderite is reacted with 40.0 L of oxygen gas? Which reactant is in excess and how much remains unreacted?

$$\left( \frac{55.0 \text{ g } FeCO_3}{115.8562 \text{ g/mol}} \right) \left( \frac{2 \text{ mol } Fe_2O_3}{4 \text{ mol } FeCO_3} \right) \left( 159.6922 \frac{\text{g}}{\text{mol}} \right) = 37.9 \text{ g } Fe_2O_3$$

$$\left( \frac{40.0 \text{ L } O_2}{22.4 \text{ L/mol}} \right) \left( \frac{2 \text{ mol } Fe_2O_3}{1 \text{ mol } O_2} \right) \left( 159.6922 \frac{\text{g}}{\text{mol}} \right) = 570.0 \text{ g } Fe_2O_3$$

$\therefore 37.9 \text{ g } Fe_2O_3$  produced,  $O_2$  is in excess

$$\left( \frac{55.0 \text{ g } FeCO_3}{115.8562 \text{ g/mol}} \right) \left( \frac{1 \text{ mol } O_2}{4 \text{ mol } FeCO_3} \right) \left( 22.4 \frac{\text{L}}{\text{mol}} \right) = 2.66 \text{ L } O_2 \text{ needed}$$

$$40.0 \text{ L} - \frac{2.66 \text{ L}}{\text{needed}} = \underline{37.3 \text{ L } O_2 \text{ remains unreacted}}$$

12. A manufacturer of bicycles has 5050 wheels, 3013 frames, and 2455 handlebars.
- a) How many bicycles can be manufactured using these parts?

2 wheels + 1 frame + 1 handlebar  $\Rightarrow$  1 bike

$$5050 \text{ wheels} \left( \frac{1 \text{ bike}}{2 \text{ wheels}} \right) = 2525 \text{ bikes}$$

$$3013 \text{ frames} \left( \frac{1 \text{ bike}}{1 \text{ frame}} \right) = 3013$$

$$2455 \text{ handlebars} \left( \frac{1 \text{ bike}}{1 \text{ handlebar}} \right) = 2455 \text{ bikes}$$

$\therefore 2455 \text{ bikes can be manufactured}$

- b) How many parts of each kind are left over?

$$2455 \text{ bikes} \left( \frac{2 \text{ wheels}}{1 \text{ bike}} \right) = 4910 \text{ wheels needed}$$

$$5050 - 4910 = \boxed{140 \text{ wheels left over}}$$

$$2455 \text{ bikes} \left( \frac{1 \text{ frame}}{1 \text{ bike}} \right) = 2455 \text{ frames needed}$$

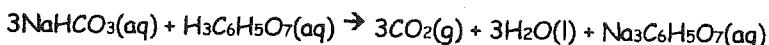
$$3013 - 2455 = \boxed{558 \text{ frames left over}}$$

$0 \text{ handlebars left over}$

- c) Which part is like a limiting reactant in that it limits the production of bicycles?

The handlebars ran out first, they are the limiting reactant.

13. The fizz produced when an Alka-Seltzer tablet is dissolved in water is due to the reaction between sodium bicarbonate and citric acid:



In a certain experiment 1.00 g of sodium bicarbonate and 1.00 g of citric acid are allowed to react.

- a) What volume of carbon dioxide is formed?

$$\left( \frac{1.00 \text{ g NaHCO}_3}{84.00691 \text{ g/mol}} \right) \left( \frac{3 \text{ mol CO}_2}{3 \text{ mol NaHCO}_3} \right) \left( \frac{22.4 \text{ L}}{\text{mol}} \right) = 0.267 \text{ L CO}_2$$

$$\left( \frac{1.00 \text{ g H}_3\text{C}_6\text{H}_5\text{O}_7}{192.12532 \text{ g/mol}} \right) \left( \frac{3 \text{ mol CO}_2}{1 \text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7} \right) \left( \frac{22.4 \text{ L}}{\text{mol}} \right) = 0.350 \text{ L CO}_2$$

∴ 0.267 L CO<sub>2</sub> is formed

- b) Which reactant is the limiting reactant?

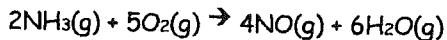
NaHCO<sub>3</sub> is the limiting reactant

- c) How much of the excess reactant remains after the limiting reactant is completely consumed?

$$\left( \frac{1.00 \text{ g NaHCO}_3}{84.00691 \text{ g/mol}} \right) \left( \frac{1 \text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7}{3 \text{ mol NaHCO}_3} \right) \left( \frac{192.12532 \text{ g}}{\text{mol}} \right) = 0.762 \text{ g needed}$$

$$\frac{1.00 \text{ g}}{\text{available}} - \frac{0.762 \text{ g}}{\text{needed}} = \boxed{0.24 \text{ g H}_3\text{C}_6\text{H}_5\text{O}_7 \text{ remains}}$$

14. One of the steps in the commercial process for converting ammonia to nitric acid involves the conversion of ammonia to nitrogen monoxide:



In a certain experiment 2.50 g of ammonia reacts with 2.85 g of oxygen.

- a) What mass of nitrogen monoxide is formed?

$$\left( \frac{2.50 \text{ g NH}_3}{17.03052 \text{ g/mol}} \right) \left( \frac{4 \text{ mol NO}}{2 \text{ mol NH}_3} \right) \left( \frac{30.0061 \text{ g}}{\text{mol}} \right) = 8.81 \text{ g NO}$$

$$\left( \frac{2.85 \text{ g O}_2}{31.9988 \text{ g/mol}} \right) \left( \frac{4 \text{ mol NO}}{5 \text{ mol O}_2} \right) \left( \frac{30.0061 \text{ g}}{\text{mol}} \right) = 2.14 \text{ g NO}$$

∴ 2.14 g NO is formed

- b) Which reactant is the limiting reactant?

O<sub>2</sub> is the limiting reactant

- c) How much of the excess reactant remains after the limiting reactant is completely consumed?

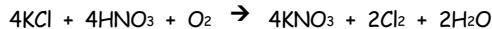
$$\left( \frac{2.85 \text{ g O}_2}{31.9988 \text{ g/mol}} \right) \left( \frac{2 \text{ mol NH}_3}{5 \text{ mol O}_2} \right) \left( \frac{17.03052 \text{ g}}{\text{mol}} \right) = 0.607 \text{ g needed}$$

$$\frac{2.50 \text{ g}}{\text{available}} - \frac{0.607 \text{ g}}{\text{needed}} = \boxed{1.89 \text{ g NH}_3 \text{ remains}}$$

# Stoichiometry - Limiting Reactants

1. Hydrogen gas can be produced in the laboratory by the reaction of magnesium metal with hydrochloric acid.
  - a) How many grams of hydrogen can be produced when 4.00 g of hydrochloric acid are added to 3.00 g of magnesium?
  - b) What is the volume of this hydrogen at standard conditions?

2. Potassium nitrate is widely used as a fertilizer because it provides two essential elements, potassium and nitrogen. It is made by mixing potassium chloride and nitric acid in the presence of oxygen according to the equation:



How many kilograms of potassium nitrate will be produced from 50.0 kg of potassium chloride and 50.0 kg of nitric acid? An important by-product is chlorine. How many kilograms of chlorine will be produced?

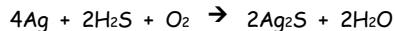
3. Phosphorus forms a compound similar to ammonia. The compound has the formula  $\text{PH}_3$  and is called phosphine. It can be prepared by the reaction:



If 20.0 g of phosphorus and 50.0 g of sodium hydroxide are reacted with excess water, how many grams of phosphine will be obtained?

4. Bromine can be prepared by adding chlorine to an aqueous solution of sodium bromide. How many grams of bromine are formed if 25.0 g of sodium bromide and 25.0 g of chlorine are reacted?

5. Silver tarnishes in the presence of hydrogen sulfide, a gas that originates from the decay of food, because of the reaction:

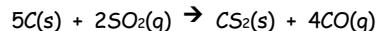


The black product, silver sulfide, is the "tarnish". If 25.00 g of silver, 5.00 g of hydrogen sulfide, and 4.00 g of oxygen are present in a reaction mixture, which one is the limiting reactant, and what mass of silver sulfide is produced?

6. Sulfur dioxide can be produced from the reaction of hydrogen sulfide and oxygen as shown by the following reaction:  $2\text{H}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{SO}_2 + 2\text{H}_2\text{O}$

- a) How many grams of sulfur dioxide can be produced from 70.0 g of hydrogen sulfide and 125 g of oxygen.
- b) How many grams of excess reactant are left over after the reaction is complete?

7. What mass of carbon disulfide is produced when 17.5 g of carbon are reacted with 39.5 g of sulfur dioxide according to the equation:

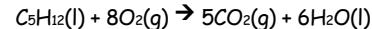


8. What mass of  $\text{P}_4$  is produced when 41.5 g of  $\text{Ca}_3(\text{PO}_4)_2$ , 26.5 g of  $\text{SiO}_2$  and 7.80 g of C

are reacted according to the equation:

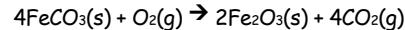


9. What volume of carbon dioxide, measured at STP, can be produced when 15.65 g of pentane is reacted with 40.0 L of oxygen, measured at STP, according to the equation:



10. What mass of hydrogen chloride gas is produced when 4.50 g of hydrogen and 140.0 g of chlorine are reacted. Which reactant is in excess and how much remains unreacted?

11. The roasting of siderite ore,  $\text{FeCO}_3$ , produces ferric oxide:



What mass of ferric oxide is produced when 55.0 g of siderite is reacted with 40.0 L of oxygen gas? Which reactant is in excess and how much remains unreacted?

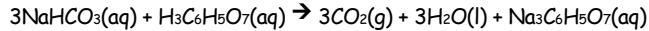
12. A manufacturer of bicycles has 5050 wheels, 3013 frames, and 2455 handlebars.

- a) How many bicycles can be manufactured using these parts?

- b) How many parts of each kind are left over?

- c) Which part is like a limiting reactant in that it limits the production of bicycles?

13. The fizz produced when an Alka-Seltzer tablet is dissolved in water is due to the reaction between sodium bicarbonate and citric acid:



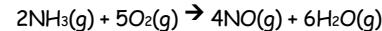
In a certain experiment 1.00 g of sodium bicarbonate and 1.00 g of citric acid are allowed to react.

- a) What volume of carbon dioxide is formed?

- b) Which reactant is the limiting reactant?

- c) How much of the excess reactant remains after the limiting reactant is completely consumed?

14. One of the steps in the commercial process for converting ammonia to nitric acid involves the conversion of ammonia to nitrogen monoxide:



In a certain experiment 2.50 g of ammonia reacts with 2.85 g of oxygen.

- a) What mass of nitrogen monoxide is formed?

- b) Which reactant is the limiting reactant?

- c) How much of the excess reactant remains after the limiting reactant is completely consumed?