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GRADE 12

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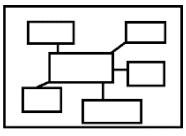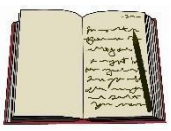
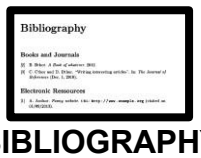
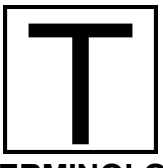
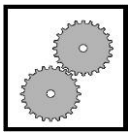
TOPICS

1. Electric Circuits
2. Organic Nomenclature
3. Organic Physical Properties
4. Organic Reactions

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ICON DESCRIPTION

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TOPICS

Electric Circuits

DATA FOR PHYSICAL SCIENCES GRADE 12 PAPER (PHYSICS)

TABLE 1: PHYSICAL CONSTANTS*:*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekrag versnelling*	g	9,8 $m \cdot s^{-2}$
Gravitational constant *Swaartekrag konstante*	G	6,67 x 10^{-11} $N \square m^2 \square kg^{-2}$
Radius of Earth *Straal van Aarde*	RE	6,38 x 10^6 m
Coulomb's constant *Coulomb se konstante*	K	9,0 x 10^9 $N \square m^2 \cdot C^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	3,0 x 10^8 $m \cdot s^{-1}$
Charge on electron *Lading op electron*	e	-1,6 x 10^{-19} C
Electron mass *Elektron massa*	me	9,11 x 10^{-31} kg

ELECTRIC CIRCUITS FORMULA SHEET

$R = \frac{V}{I}$	$emk(\varepsilon) = I(R + r)$
$R = r_1 + r_2 + r_3 + \ldots$ $\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \ldots$	$q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

Examination guideline

Electric Circuits

(This section must be read in conjunction with the CAPS, p. 88–89 & 121.)

Ohm's law

- State Ohm's law in words: **The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature**.
- Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.
- State the difference between ohmic conductors and non-ohmic conductors and give an example of each.
- Solve problems using $R = \frac{V}{I}$ for series and parallel circuits (maximum four resistors).

Power, energy

- Define *power* **as the rate at which work is done.**
- Solve problems using $P = \frac{W}{\Delta t}$
- Solve problems using $P = VI$, $P = I^2R$ or $P = \frac{V^2}{R}$
- Solve circuit problems involving the concepts of power and electrical energy.
- Deduce that the kilowatt hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.
- Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

Internal resistance, series and parallel networks

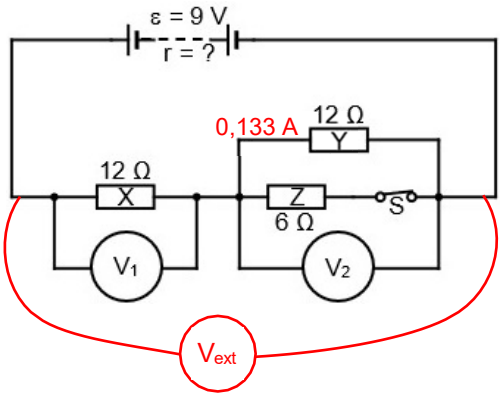
- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors excluding internal resistance).
- Define the term *emf* **as the maximum energy provided by a battery per unit charge passing through it.**
- Solve circuit problems using $\varepsilon = V_{load} + V_{internal\ resistance}$ or $\varepsilon = IR_{ext} + Ir$.
- Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).

TERMS AND DEFINITIONS	
Ohm's law	The potentiaL difference across a conductor is directly proportional to the current in the conductor at constant temperature. In symbols: R = $\frac{V}{I}$ The units: Ω = $V \cdot A^{-1}$
Emf	Maximum energy provided / amount of work done by a battery per coulomb/unit charge passing through it. (It is the potential difference across the ends of a battery when there is NO current in the circuit.)
Terminal potential difference	The energy transferred to or the work done per coulomb of charge passing through the battery when the battery delivers a current. (It is the potential difference across the terminals of a battery when there IS a current in the circuit.)
Ohmic conductors	A conductor that obeys Ohm's law, i.e., the ratio of potential difference to current remains constant. (Resistance of the conductor remains constant.)
Non-ohmic conductors	A conductor that does NOT obey Ohm's law, i.e., the ratio of potential difference to current does NOT remain constant. (Resistance of the conductor increases as the current increases, e.g. a bulb.)
Potential difference	Potential difference is the amount of work done (or energy transferred) per coulomb of charge. It is measured in volt (V). In symbols: V = $\frac{W}{Q}$ The units: $V = J \cdot C^{-1}$
Current	Current is the rate of flow of charge. It is measured in ampere (A). In symbols: I = $\frac{Q}{\Delta t}$ The units: $A = C \cdot s^{-1}$
Resistance	Resistance is the opposition to the flow of charge (electric current). It is measured in ohm (Ω) and can be calculated by using the ratio of potential difference (V) to current (I). In symbols: R = $\frac{V}{I}$ The units: Ω = $V \cdot A^{-1}$
Resistors in series	The total resistance of resistors in series is given by: $R_T = R_1 + R_2 + \cdots$ OR $R_S = R_1 + R_2 + \cdots$
Resistors in parallel	The effective resistance (do NOT use the word "total") of resistors in parallel is given by: $\frac{1}{RP} = \frac{1}{R1} + \frac{1}{R2} + \cdots$
Internal resistance	The resistance within a battery that causes a drop in the potential difference across the battery when there is a current in the circuit.
Power	Power is the rate at which work is done or rate at which energy is transferred. It is measured in watt (W). In symbols: P = $\frac{W}{\Delta t}$ The units: $W = J \cdot s^{-1}$
	Other formulae for power: $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

kilowatt hour (kWh) (This is an energy unit related to the formula $W = P\Delta t$.)	It is the use of 1 kilowatt of electricity for 1 hour.	
Other energy formulae (electric circuits)	$W=VQ$ $W=VI\Delta t$	$W = I^2R\Delta t$ $W = \frac{V^2}{R}\Delta t$

CONTENT

Example 2: Electric circuits



Consider the circuit diagram on the right. Two resistors, **Y** and **Z** of 12 Ω and 6 Ω respectively, are connected in parallel. A closed switch **S** is connected in series with **Z**. A third resistor, **X**, of 12 Ω is connected in series with **Y** and **Z**. Voltmeters **1** and **2** are connected across **X**, **Y** and **Z** as shown. The current in **Y** is 0,133 A. The battery has an unknown internal resistance *r* and its emf is 9 V. Calculate the following: (1) The reading on **V2**;
(2) the reading on **V1**; and (3) the internal resistance, *r*, of the battery.

Steps	Critical thinking	What do you have?
1 & 2	• A circuit diagram is given. If any information in the question is not indicated on the diagram, add it to the diagram. In this case it is the branch current in **Y**, which is a crucial piece of information. • A good habit is to add information to the circuit diagram as you solve the questions. This makes it more "visual" and helps to see the relationships between different numbers.	The following are **important facts** at this stage: • **V_1** is only applicable to **X**. • **V_2** is only applicable to the parallel set of resistors **Y** and **Z**; also, to each of them. • If **V_{ext}** represents the voltmeter reading across all three resistors, $V_{ext} = V_1 + V_2$. • Due to the internal resistance, $V_{emf} = V_{ext} + V_{int}$. • It is easy to determine the current in **Z** from the following: **V_2** is the same for **Y** and **Z**. $\therefore V_2 = R_Y I_Y = R_Z I_Z$ R_Y is $2R_Z$ I_Y is $\frac{1}{2}I_Z$
		As you solve the questions in steps six and seven, more arguments will surface.

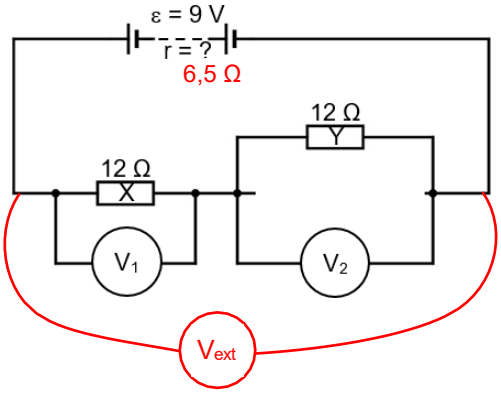
3 5	In contrast with the example on vertical motion, it is usually better to write down the different known values on the circuit diagram itself than making a list. The main reason is to make it easier to see the relationships between the variables of the circuit. However, if you are more comfortable with a list, draw up a list. In addition to this, we do not use "directions" in electric circuit calculations, but it is important to pick the correct variables for each calculation.	Refer to the circuit diagram.
4	We are dealing with potential difference, emf, current, resistance, etc. in this question. Hence, the equation on the right is mainly used, but **correctly applied to each solution**. Note how the three variables *R*, *V* and I are applied to deal with the "same situation in each solution". This way of thinking is described in detail in the section on electric circuits under "*A simple way of how a circuit (direct current) works*" where the **examples of calculations** are given.	$R = \frac{V}{I}$
6 & 7	**For question (1): Calculate V_2** • Current in **Y** is known. • Resistance of **Y** is known.	$R_Y = \frac{V_2}{I_Y}$ $12 = \frac{V_2}{0{,}133}$ $V_2 = 1{,}6\ V$ Remember to enter the reading on **V_2** on your circuit diagram.
	For question (2): Calculate V_1 • You need the resistance of **X** (known) and the current in **X** (unknown) to calculate **V_1**. • The current in **X** is the main current. If you know both branch currents in **Y** and **Z**, you have the main current by adding them. • The first step is then to determine the branch current in **Z**.	We can use I_Z = 2 x 0,133 = 0,266 A as explained before, or the following calculation: $R_Z = \frac{V_2}{I_Z}$ $6 = \frac{1{,}6}{I_Z}$ $I_Z = 0{,}267\ A$ $I_X = I_T = 0{,}133 + 0{,}267 = 0{,}4\ A$ Remember to write down I_Z and I_T on your circuit diagram. $R_X = \frac{V_1}{I_X}$ $12 = \frac{V_1}{0{,}4}$ $V_1 = 4{,}8\ V$ Remember to write down V_1 on your circuit diagram.
	For question (3): Calculate *r* • You need the potential drop across the battery (**V_{int}**) and the main current in the battery to calculate the internal resistance *r*. • To get **V_{int}** you must subtract the external potential difference **V_{ext}** from the emf.	$V_{ext} = V_1 + V_2 = 4{,}8 + 1{,}6 = 6{,}4\ V$ $V_{int} = V_{emf} - V_{ext}$ $= 9 - 6{,}4$ $= 2{,}6\ V$ $r = \frac{V_{int}}{I_T}$
		$-\frac{2{,}6}{0{,}4}$ $= 6{,}5\ \Omega$
	For those who like to use the formula $\varepsilon = I(R + r)$ to calculate question (3), the following: • Note the meaning of the symbols:	$\varepsilon = I(R + r)$ $= IR + Ir$ $= V_{ext} + Ir$

	o I is the total current. o R and r are total external resistance and internal resistance respectively. o ε is the emf of the battery. • This formula is the same as $\varepsilon = IR + Ir$, where: o IR is the same as $\mathbf{V_{ext}}$; and o Ir is the same as $\mathbf{V_{int}}$. • After you have calculated questions (1) and (2) as shown above, you know the total current and the $\mathbf{V_{ext}}$, from which question (3) can be solved easily.	$= V_1 + V_2 + Ir$ $\therefore 9 = 4{,}8 + 1{,}6 + 0{,}4r$ $r = 6{,}5\ \Omega$
8	In electric circuit questions we do not deal with vectors and scalars in the same sense as with vertical motion for example. Hence, this step is usually not required in calculations.	

Example 3: Electric circuits

Let's use the same circuit as in example 2 above, but change it into a question in which you must **explain** how the reading on each of $\mathbf{V_1}$ and $\mathbf{V_2}$ change if switch **S** is opened.

Example 3 Part 1



Let's first look at **calculations** to address this type of situation before we address the explanation type of answer. From the previous example, we know that the internal resistance, *r*, of the battery is 6,5 Ω. Opening the switch is the same as ignoring resistor **Z**. Therefore, the circuit diagram looks like the one on the right-hand side. The following set of calculations (six steps) can be done to determine the reading on each of $\mathbf{V_1}$ and $\mathbf{V_2}$.

1 Total resistance:
$R_T = R_X + R_Y + r$
$= 12 + 12 + 6{,}5$
$= 30{,}5\ \Omega$

2 Total current:
$R_T = \frac{V_{emf}}{I_T}$
$30{,}5 = \frac{9}{I_T}$
$I_T = 0{,}295\ A$

3 Reading on $\mathbf{V_1}$:
$R_X = \frac{V_1}{I_T}$
$12 = \frac{V_1}{0{,}295}$
$V_1 = 3{,}54\ V$

4 Potential difference across battery:
$r = \frac{V_{int}}{I_T}$
$6{,}5 = \frac{V_{int}}{0{,}295}$
$V_{int} = 1{,}92\ V$

5 External potential difference:
$V_{ext} = V_{emf} - V_{int}$
$= 9 - 1{,}92$
$= 7{,}08\ V$

6 Reading on $\mathbf{V_2}$:
$V_1 + V_2 = V_{ext}$
$3{,}54 + V_2 = 7{,}08$
$V_2 = 3{,}54\ V$

Note: It is easy to see that $\mathbf{V_2}$ must be the same as $\mathbf{V_1}$ after step three, because equal resistors in series carry the same current.

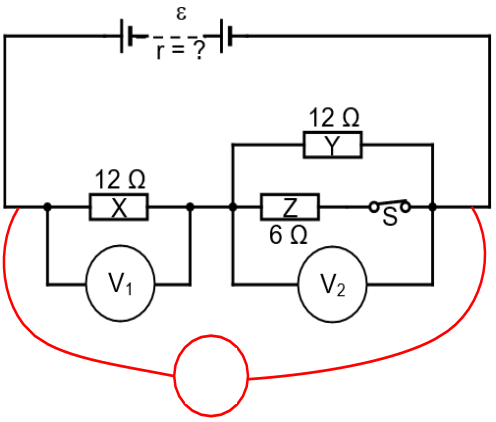
Let's look at a comparison between the readings for a closed (example 2) and an open switch (example 3 part 1).

	S closed	**S** open	**Comparison**
V_1	4,8 V	3,54 V	Smaller
V_2	1,6 V	3,54 V	Greater
I_T	0,4 A	0,295 A	Smaller
V_{ext}	6,4 V	7,08 V	Greater
V_{int}	2,6 V	1,92 V	Smaller

We can now go back to discuss the approach to an **explanation**. The question might be something like this:

Example 3 Part 2

Consider the circuit diagram on the right. Two resistors, **Y** and **Z** of 12 Ω and 6 Ω respectively, are connected in parallel. A closed switch **S** is connected in series with **Z**. A third resistor, **X**, of 12 Ω is connected in series with **Y** and **Z**. Voltmeters **1** and **2** are connected across **X**, **Y** and **Z** as shown, and each one displays a reading. The battery has an internal resistance *r* and an emf ε. Switch **S** is then **opened**. How does the reading on each of $\mathbf{V_1}$ and $\mathbf{V_2}$ change? Explain your answers.



Steps	Critical thinking	What do you have
All	• If a switch is opened, it generally affects: o The resistance of a circuit; o The main current, and branch currents if any; and o $\mathbf{V_1}$ and $\mathbf{V_2}$ (and other variables such as power, energy, etc.). • In an explanation, one usually follows the above-mentioned order, but each question or situation must be analysed based on the factors that are present. • When the switch is opened in this circuit, the following happens: o Resistor **Z** is effectively removed; o The **total resistance increases**; and o The **total current decreases** (more resistance; smaller current). On the right are a few calculations to show you why the total resistance increases from the closed switch to the open switch. This corresponds with the result of calculation 1 in example 3, part 1.	With **S** closed: Effective resistance of **Y** and **Z**: $\frac{1}{Rp} = \frac{1}{R_Y} + \frac{1}{R_Z}$ $= \frac{1}{12} + \frac{1}{6}$ $\therefore R_P = 4\ \Omega$ The total external resistance is: $R_{ext} = R_X + R_P = 12 + 4$ $= 16\ \Omega$ With **S** open: Only **Y** is present and the total external resistance is: $R_{ext} = R_X + R_Y = 12 + 12$ $= 24\ \Omega$ The total resistance of the circuit is the sum of internal and external resistance; hence, R_T increases.
All	What is the effect on the voltmeter readings? • Let's consider $\mathbf{V_1}$: o The resistance of **X** is the same as before; o The current in **X** is the total current; and o The total current is less than before. • Note how only two of the three variables in the equation on the right have changed. This makes it easy to explain the effect on $\mathbf{V_1}$ if the current changes. • Let's consider $\mathbf{V_2}$: o The resistance between the arms of $\mathbf{V_2}$ increases. o Current is problematic. With a closed switch, resistor **Y** carries a branch current. With an open switch, it carries the total current, which is less than the total current with a closed switch. The problem is: *Is this current less than or greater than the branch current with a closed switch?* Without values you cannot really tell. o This presents us with a problem. If you do not know what happens to one of the variables, you cannot tell what happens to $\mathbf{V_2}$. Therefore, we must use another argument to determine the effect on $\mathbf{V_2}$.	$V_1 = R_X I_T$ ← Smaller ↑ Same $\mathbf{V_1}$ is smaller than before. See steps 2 and 3 of example 3, part 1 to guide you. This equation can also be written as a direct proportionality: $V_1 \propto I_T$ $V_2 = RI$ ← ?? ↑ Greater Effect on $\mathbf{V_2}$ cannot be explained.

ACTIVITIES

ACTIVITY 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the correct answer.

1.1 Which ONE of the following phrases describes the emf of a battery?

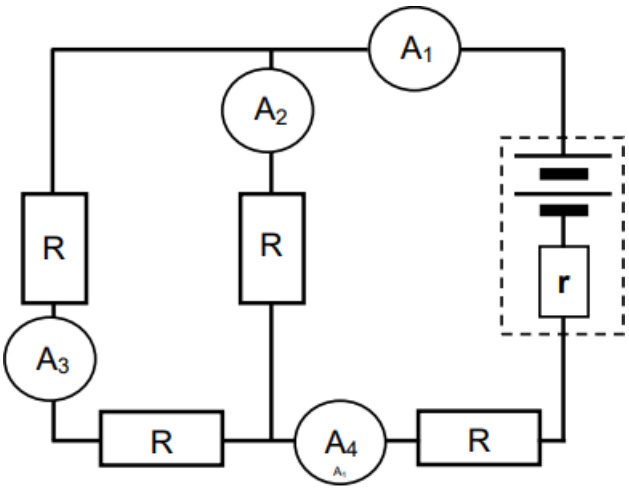
A Energy supplied per unit time

B Charge transferred per unit time

C Current supplied per unit charge

D Maximum energy supplied per unit charge (2)

1.2 The diagram below represents a circuit in which all the external resistors have the same resistance.



Which ONE of the ammeters in the circuit will have the LOWEST reading?

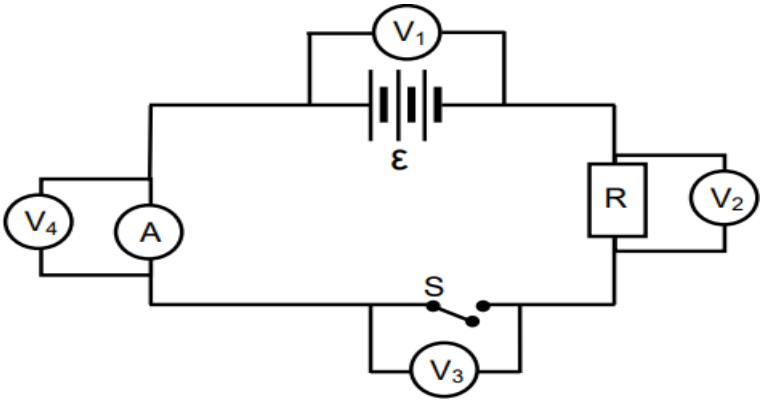
A A_1

B A_2

C A_3

D A_4 (2)

1.3 Four voltmeters, **V1**, **V2**, **V3** and **V4**, are connected in a circuit, as shown in the diagram below.



Which voltmeter(s) will have the same reading as voltmeter V1 when the switch is open?

A V2 only

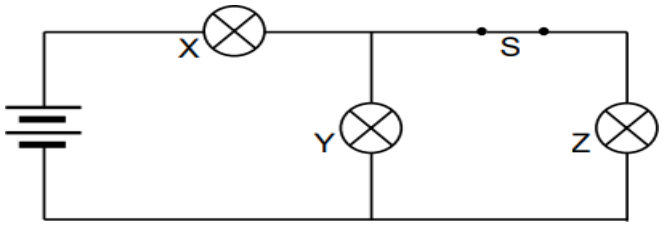
B V3 only

C V4 only

D V3 and V4 (2)

1.4 Three identical light bulbs, **X**, **Y** and **Z**, are connected in a circuit, as shown in the diagram below. Switch **S** is initially closed.

Ignore the internal resistance of the battery.

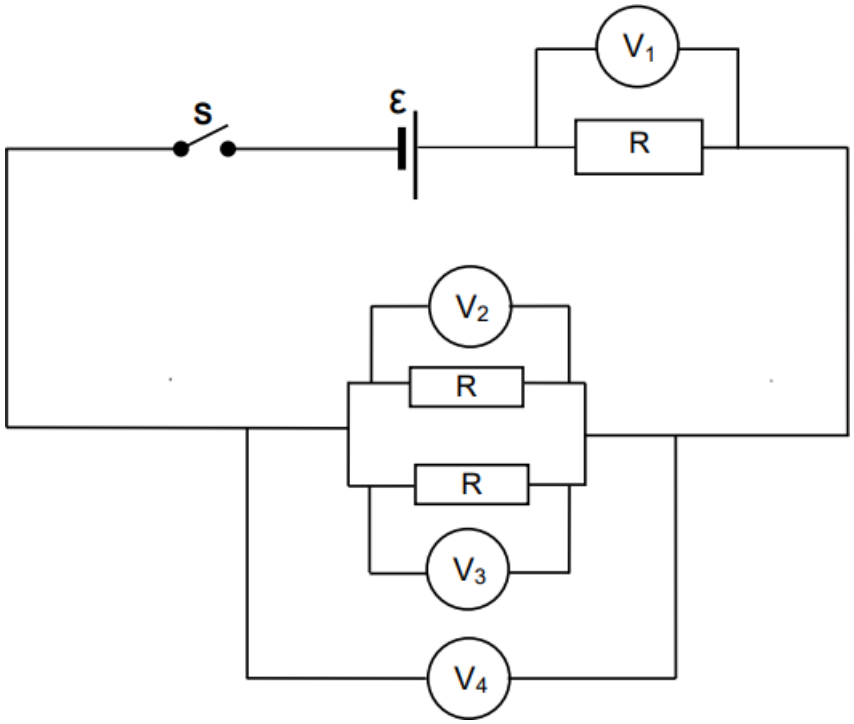


Switch **S** is now opened. How will the brightness of bulbs **X** and **Y** be affected?

	BRIGHTNESS OF BULB X	**BRIGHTNESS OF BULB Y**
A	Increases	Decreases
B	Decreases	Increases
C	Increases	Increases
D	Decreases	Decreases

(2)

1.5 In the circuit diagram shown below all the resistors are IDENTICAL. Ignore the internal resistance of the cell. Which Voltmeter will have the highest reading when switch S is closed.



A V_1

B V_2

C V_3

D V_4 (2)

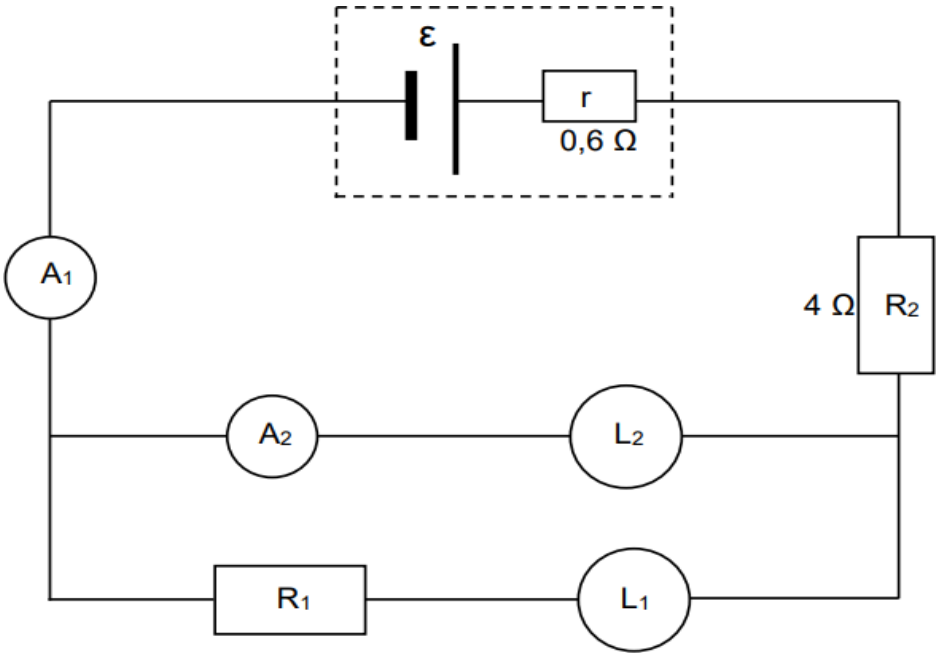
[10]

ACTIVITY 2

L_1 and **L_2** are two light bulbs that have the following ratings:

L_1: 36 W ; 20 V and L_2: 48 W ; 32 V

The two bulbs are connected as shown in the circuit diagram below. The battery has an internal resistance of 0,6 Ω while the conducting wires and the ammeters have negligible resistance. **R_1** and **R_2** are resistors.



2.1 Define the term power. (2)

2.2 If both light bulbs operate RATED, calculate the:

2.2.1 Reading on ammeter **A_2** (3)

2.2.2 Reading on ammeter **A_1** (3)

2.2.3 Resistance of resistor **R_1** (4)

2.2.4 Emf of the battery (4)

2.3 Bulb **L_1** burns out after a while. Assume that the resistance of bulb **L_2** remains constant.

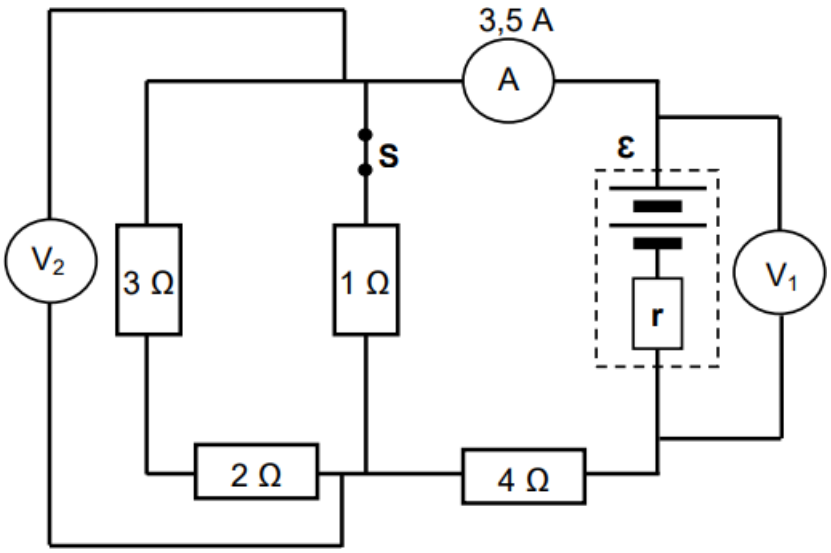
Will bulb **L2** continue to glow after bulb **L1** burns out? Choose from YES or NO.

Support your answer with a suitable calculation. (5)

[21]

ACTIVITY 3

The circuit diagram below shows four resistors connected to a battery of emf **ε** and internal resistance **r**. The resistances of the ammeter and the connecting wires are negligible, while the voltmeters have very high resistances.



3.1 State Ohm's law in words. (2)

Switch **S** is CLOSED.

3.2 The reading on the ammeter is 3,5 A

3.2.1 Calculate the total external resistance of the circuit. (4)

3.2.2 Calculate the reading on voltmeter $\mathbf{V_1}$. (3)

3.2.3 How does the reading on voltmeter V_2 compare to the reading on voltmeter $\mathbf{V_1}$? Choose from SMALLER THAN, EQUAL TO or GREATER THAN. (1)

3.3 A learner concludes that the emf of the battery is equal to the reading on voltmeter $\mathbf{V_1}$.

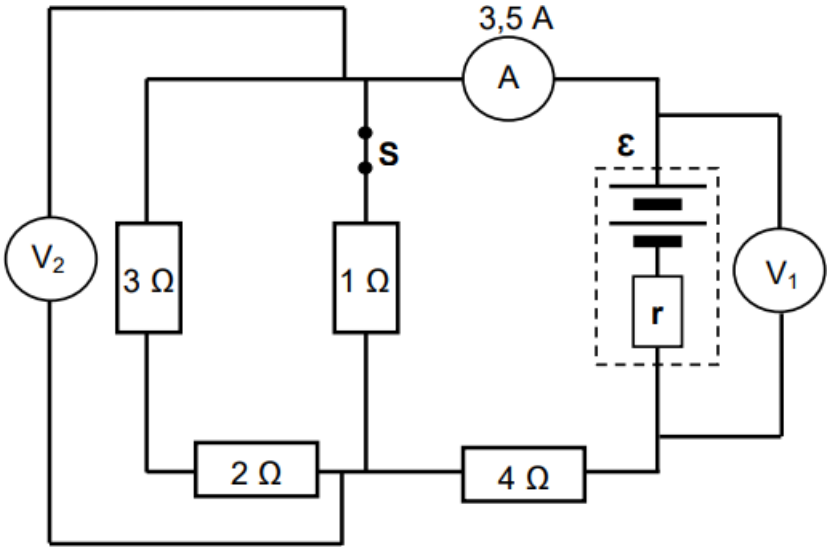
3.3.1 Define the term emf. (2)

3.3.2 Is the learner's conclusion CORRECT? Choose from YES or NO. (1)

3.3.3 Give a reason for the answer to QUESTION 3.3.2. (1)

Switch **S** is now removed and replaced by voltmeter $\mathbf{V_2}$, as shown in the circuit diagram below.

3.1 How will EACH of the following change?



Choose from INCREASES, DECREASES or REMAINS THE SAME.

3.1.1 The power dissipated by the 4 Ω resistor (1)

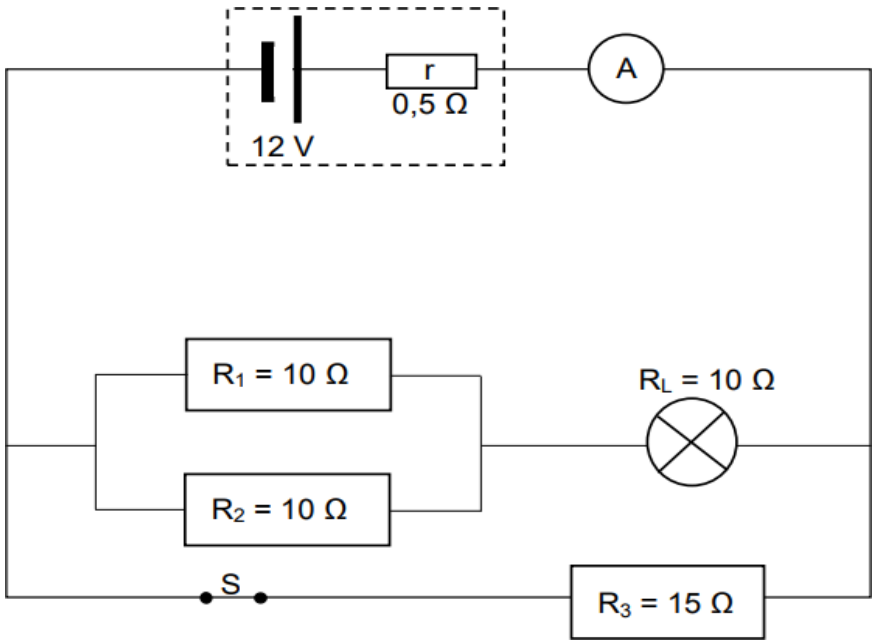
3.1.2 The reading on voltmeter $\mathbf{V_1}$ (1)

3.2 The reading on voltmeter $\mathbf{V_1}$ (4)

[20]

ACTIVITY 4

The circuit diagram below shows a battery with an emf of 12 V and an internal resistance of 0,5 Ω connected to three resistors, a light bulb, a switch, an ammeter and connecting wires. The ammeter and connecting wires have negligible resistance.



4.1 State *Ohm's law* in words. (2)

Switch **S** is initially **CLOSED**

4.2 Calculate the:

4.2.1 Total external resistance of the circuit. (5)

4.2.2 Reading on the ammeter (3)

4.2.3 Power dissipated by resistor **R3**
(4)

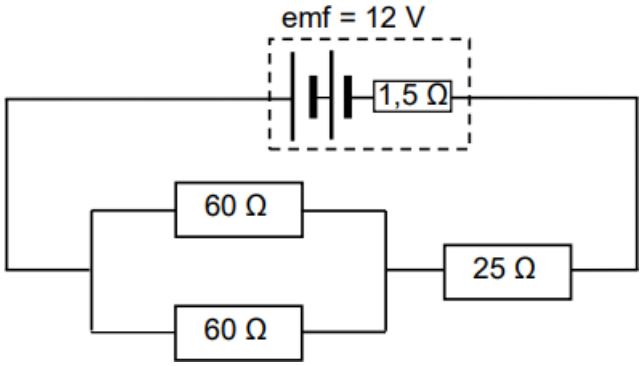
4.3 Switch **S** is now OPENED.

4.3.1 If the resistance of the light bulb remains constant, how will the brightness of the light bulb be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

4.3.2 Explain the answer to QUESTION 4.3.1. (3)
[18]

ACTIVITY 5

In the circuit represented below, two 60 Ω resistors connected in parallel are connected in series with a 25 Ω resistor. The battery has an emf of 12 V and an internal resistance of 1,5 Ω.



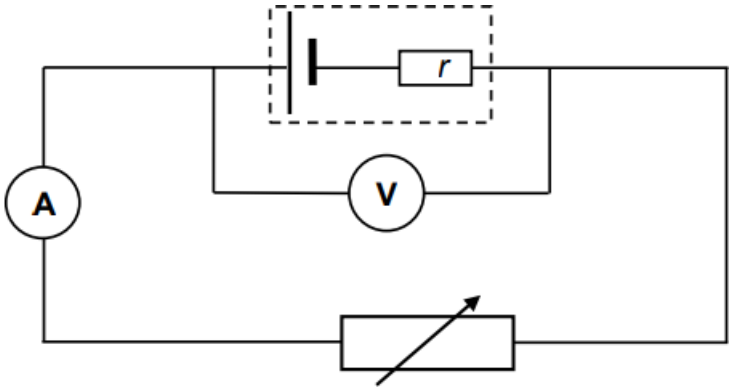
5.1 Calculate the:

5.1.1 Equivalent resistance of the parallel combination (3)

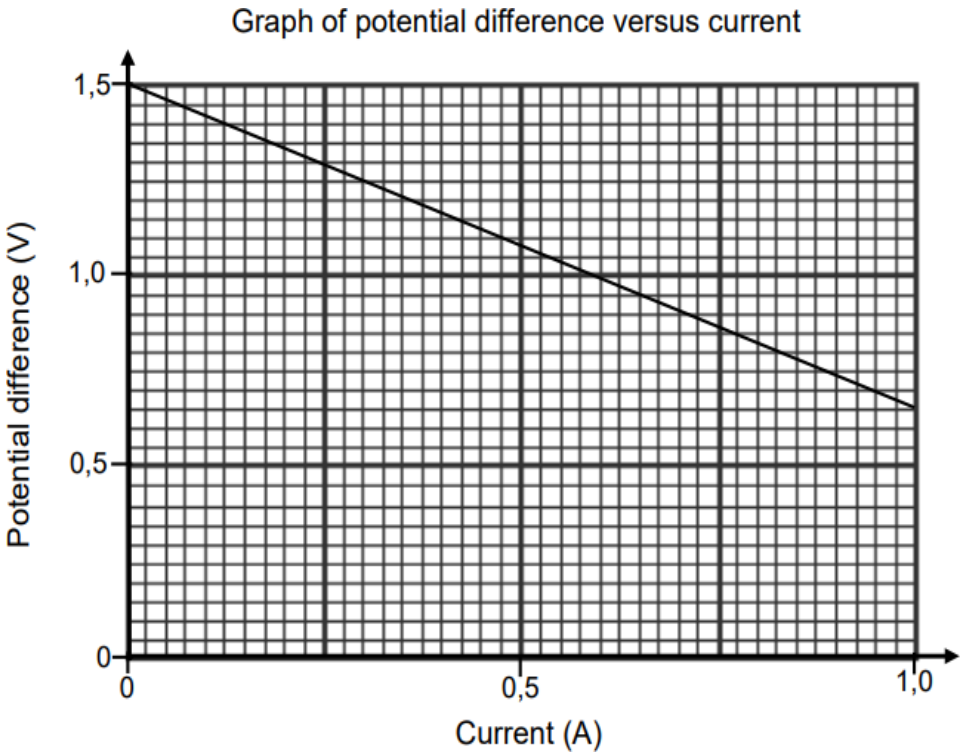
5.1.2 Total current in the circuit (5)

5.1.3 Potential difference across the parallel resistors (3)

5.2 Learners conduct an investigation to determine the emf and internal resistance (r) of a battery. They set up a circuit as shown in the diagram below and measure the potential difference using the voltmeter for different currents in the circuit.



The results obtained are shown in the graph below.



5.2.1 Use the graph to determine the emf of the battery. (1)

5.2.2 Calculate the gradient of the graph. (3)

5.2.3 Which physical quantity is represented by the magnitude of the gradient of the graph? (2)

5.2.4 How does the voltmeter reading change as the ammeter reading increases? Write down INCREASES, DECREASES or REMAINS THE SAME. Use the formula emf = IR + Ir to explain the answer. (3)

[20]

JENN

Training and Consultancy

The path to enlightened education

ORGANIC CHEMISTRY

Topic

NOMENCLATURE

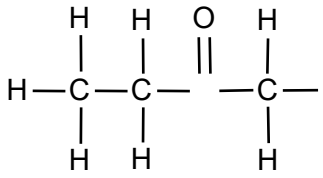
Examination guidelines

Organic Molecules
(This section must be read in conjunction with the CAPS, p. 104–116.)

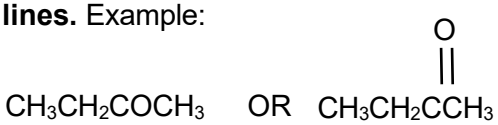
- Define organic molecules as **molecules containing carbon atoms.**

Organic molecular structures – functional groups, saturated and unsaturated structures, isomers

- Write down condensed structural formulae, structural formulae, molecular formulae and IUPAC names (up to 8 carbon atoms) for:
  - Alkanes (no ring structures)
  - Alkenes (no ring structures)
  - Alkynes
  - Halo-alkanes (primary, secondary and tertiary haloalkanes; no ring structures)
  - Alcohols (primary, secondary and tertiary alcohol)
  - Carboxylic acids
  - Esters
  - Aldehydes
  - Ketones
- Know the following definitions/terms:
  - Molecular formula: **A chemical formula that indicates the element and numbers of each of the atoms in a molecule**.
    Example: C_4H_8O
  - Structural formula: A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.
    Example:

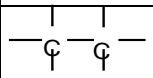
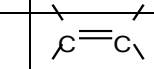
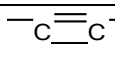
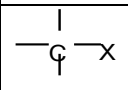
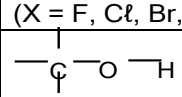
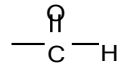
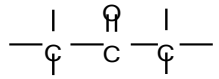
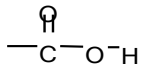
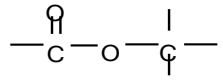


  - Condensed structural formula: **This notation shows the way in which atoms are bonded together in the molecule but DOES NOT SHOW ALL bond lines.** Example:



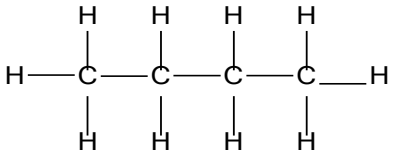
  - Hydrocarbon: **Organic compounds that consist of hydrogen and carbon only.**
  - Homologous series: **A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a CH_2 group**

- Saturated compounds: Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains
- Unsaturated compounds: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains
- Functional group: A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds

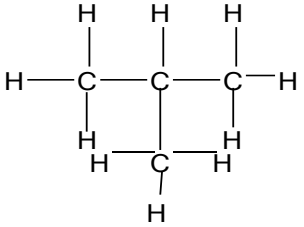
Homologous series	Structure of functional group	
	Structure	**Name/Description**
Alkanes		Only C-H and C-C single bonds
Alkenes		Carbon-carbon double bond
Alkynes		Carbon-carbon triple bond
Haloalkanes	 (X = F, Cℓ, Br, I)	Halogen atom bonded to a C atom in an alkane
Alcohols		Hydroxyl group bonded to a saturated C atom
Aldehydes		Formyl group
Ketones		Carbonyl group bonded to two C atoms
Carboxylic acids		Carboxyl group
Esters		-

- Structural isomer: Organic molecules with the same molecular formula, but different structural formulae

- Identify compounds (up to 8 carbon atoms) that are saturated, unsaturated and are structural isomers.
- Restrict structural isomers to chain isomers, positional isomers and functional isomers.
  - Chain isomers: Same molecular formula, but different types of chains, e.g. butane and 2-methylpropane

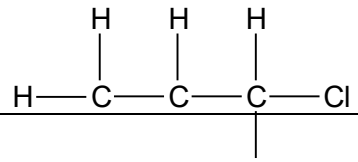


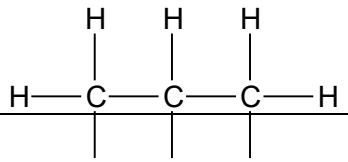
Butane

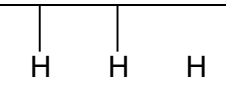


2-methylpropane

  - Positional isomers: Same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain, e.g. 1-chloropropane and 2-chloropropane or but-2-ene and but-1-ene



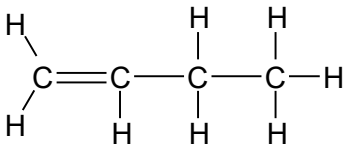




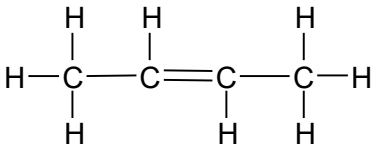
1-chloropropane



2-chloropropane

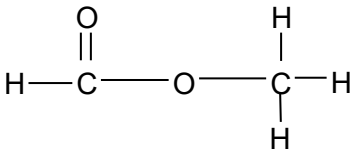


but-1-ene

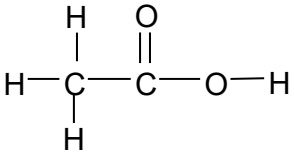


but-2-ene

- Functional isomers: Same molecular formula, but different functional groups, e.g. methyl methanoate and ethanoic acid



methyl methanoate



ethanoic acid

IUPAC naming and formulae for compounds in the homologous series above

- Write down the IUPAC name when given the structural formula or condensed structural formula.
- Write down the structural formula when given the IUPAC name or molecular formula.
- Compounds must be restricted to one functional group per compound (except haloalkanes).
- Haloalkanes are restricted to two functional groups per compound.
- Alkyl substituents (methyl- and ethyl- only) restricted to a maximum of THREE on the parent chain.
- When naming haloalkanes:
  - Halogen substituents do not get preference over alkyl groups.
  - Numbering should start from the end nearest to the first substituent.
  - When substituents, e.g. Br and Cℓ or Cℓ and methyl, have the same number when numbered from different ends of chain, preference is given to alphabetical order, e.g. bromo- over chloro-; chloro- over methyl-.
- When writing IUPAC names, substituents are written alphabetically namely bromo, chloro, ethyl, methyl. Ignore prefixes di and tri.

Structure and physical properties (boiling point, melting point, vapour pressure) relationships

- For a given example (from the above functional groups), explain the relationship between physical properties and:
  - Strength of intermolecular forces (Van der Waal's forces), i.e. hydrogen bonds, dipole-dipole forces, induced dipole forces
  - Type of functional groups
  - Chain length
  - Branched chains

Oxidation of alkanes

- State the use of alkanes as fuels.
- Write down an equation for the combustion of an alkane in excess oxygen.

Esterification

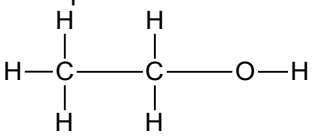
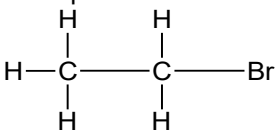
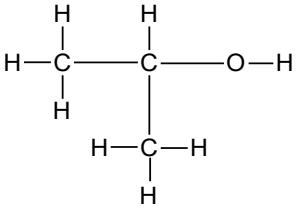
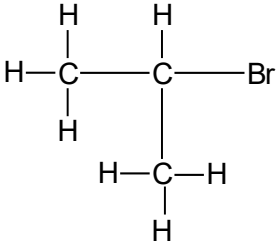
- Write down an equation, using structural formulae or condensed structural formulae, for the formation of an ester.
- Name the alcohol and carboxylic acid used and the ester formed.
- Write down reaction conditions for esterification.

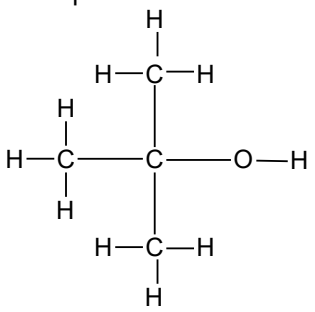
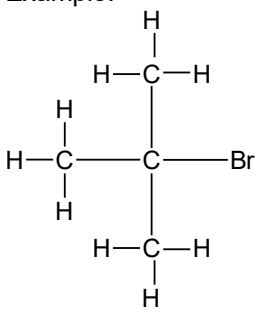
Substitution, addition and elimination reactions

- Identify reactions as elimination, substitution or addition.
- Write down, using structural formulae or condensed structural formulae, equations and reaction conditions for the following addition reactions of alkenes:
  - Hydrohalogenation:
    The addition of a hydrogen halide to an alkene
  - Halogenation:
    The reaction of a halogen (Br_2, $C\ell_2$) with a compound
  - Hydration:
    The addition of water to a compound
  - Hydrogenation:
    The addition of hydrogen to an alkene
- Identify major and minor products in the above addition reactions.
- Write down, using structural formulae or condensed structural formulae, equations and reaction conditions for the following elimination reactions:
  - Dehydrohalogenation of haloalkanes:
    The elimination of hydrogen and a halogen from a haloalkane
  - Dehydration of alcohol:
    Elimination of water from an alcohol
  - Cracking of alkanes:
    The chemical process in which longer chain hydrocarbon molecules are broken down to shorter more useful molecules.
- Identify major and minor products in the above elimination reactions.
- Write down, using structural formulae or condensed structural formulae, equations and reaction conditions for the following substitution reactions:
  - Hydrolysis of haloalkanes
    Hydrolysis: The reaction of a compound with water
  - Reactions of HX (X = Cℓ, Br) with alcohols to produce haloalkanes
  - Halogenation of alkanes
    The reaction of a halogen (Br_2, $C\ell_2$) with a compound
- Distinguish between *saturated* and *unsaturated hydrocarbons* using bromine water.

TERMS AND DEFINITIONS

TERMS AND DEFINITIONS	
Alcohol	An organic compound in which H atoms in an alkane have been substituted with hydroxyl groups (-OH groups). General formula: $C_nH_{2n+1}OH$
Aldehydes	Organic compounds have the general structure RCHO where R = H or alkyl. General formula: RCHO (R = alkyl group)
Alkane	An organic compound containing only C-H and C-C single bonds. General formula: C_nH_{2n+2}
Alkene	A compound of carbon and hydrogen that contains a carbon-carbon double bond. General formula: C_nH_{2n}
Alkyl group	A group formed by removing one H atom from an alkane.
Alkyne	A compound of carbon and hydrogen that contains a carbon-carbon triple bond.
Carbonyl group	Functional group of ketones (>C=O)
Carboxyl group	Functional group of carboxylic acids (-COOH)

Carboxylic acid	An organic compound containing a carboxyl group (-COOH group). General formula: $C_nH_{2n+1}COOH$ (or RCOOH)
Chain isomers	Compounds with the same molecular formula, but different types of chains.
Condensed structural formula	A formula that shows the way in which atoms are bonded together in the molecule but DOES NOT SHOW ALL bond lines.
Functional group	A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds.
Functional isomers	Compounds with the same molecular formula, but different functional groups.
Haloalkane (Alkyl halide)	An organic compound in which one or more H atoms in alkane have been replaced with halogen atoms. General formula: $C_nH_{2n+1}X$ (X = F, Cℓ, Br or I)
Homologous series	A series of organic compounds that can be described by the same general formula and that have the same functional group. OR A series of organic compounds in which one member differs from the next with a CH_2 group.
Hydrocarbon	Organic compounds that consist of hydrogen and carbon only.
IUPAC naming	A chemical nomenclature (set of rules) created and developed by the International **Union of Pure and Applied Chemistry** (IUPAC) generates systematic names for chemical compounds.
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule, e.g. CH_4.
Organic chemistry	Chemistry of carbon compounds. (Not examinable)
Positional isomer	Compounds with the same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain.
Primary alcohol	The C atom bonded to the hydroxyl group is bonded to ONE other C atom. Example: 
Primary haloalkane	The C atom bonded to the halogen is bonded to ONE other C atom. Example: 
Saturated compounds	Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains. OR Compounds with only single bonds between C atoms in their hydrocarbon chains.
TERMS AND DEFINITIONS	
Secondary alcohol	The C atom bonded to hydroxyl group is bonded to TWO other C atoms. Example: 
Secondary haloalkane	The C atom bonded to the halogen is bonded to ONE other C atom. Example: 

Structural formula	A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.
Structural isomer	Organic molecules with the same molecular formula, but different structural formulae.
Substituent (branch)	A group or branch attached to the longest continuous chain of C atoms in an organic compound.
Tertiary alcohol	The C atom bonded to the hydroxyl group is bonded to THREE other C atoms. Example: 
Tertiary haloalkane	The C atom bonded to the halogen is bonded to THREE other C atoms. Example: 
Unsaturated compounds	Compounds in which there are multiple bonds (double or triple bonds) between C atoms in their hydrocarbon chains.

Notes Nomenclature

WRITING IUPAC NAMES OF ORGANIC COMPOUNDS

The name of each organic molecule has three parts:

prefix	parent	suffix
Type and position of substituents	Number of C atoms in the longest chain?	Type of functional group or homologous series

Step 1: Suffix

- Determine the **functional group** in the structure of the given compound or the homologous series to which the compound belongs.
- The functional group or homologous series determines the **suffix** (last part of the name).

Step 2: Parent name

- The number of C atoms in the longest carbon chain that contains the functional group determines the **parent name**.
- Count the number of C atoms in the longest chain containing the functional group.

Number of carbon atoms	1	2	3	4	5	6	7	8
Parent name	meth	eth	prop	but	pent	hex	hept	oct

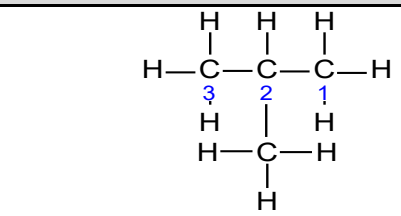
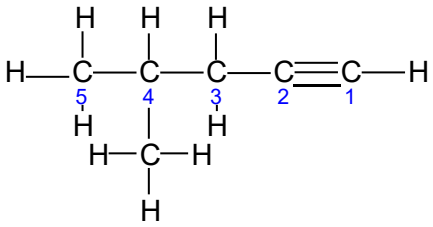
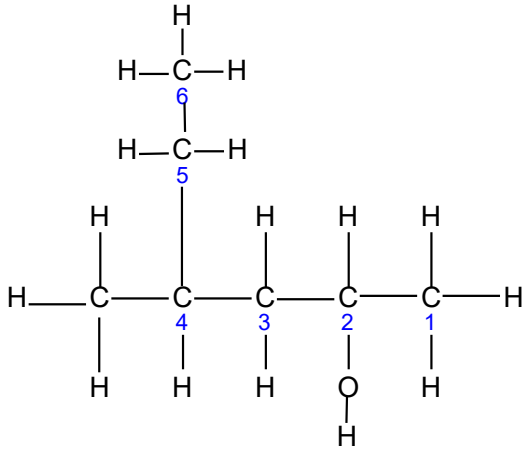
- **Alkanes and haloalkanes:** Number from the side that will give the substituents the smallest numbers.
- **Alkenes, alkynes, alcohols, ketones:** Number from the side that will the functional group the smallest number. The functional group receives a number that is written

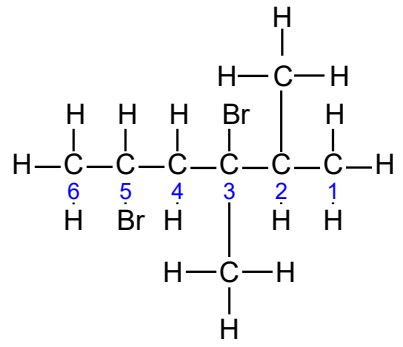
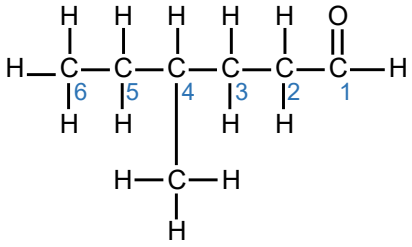
between parent name and suffix.

- **Aldehydes and carboxylic acids:** Number from the C atom that forms part of the functional group.
- **Esters:** To determine the first part of the name, count the C atoms attached to the single bonded O atom of the functional group. Add *–yl* to this part e.g. ethyl.
  To determine the last part of the name, number from the C atom bonded to the O atom with a double bond. Add the *-anoate* to this part e.g. but**anoate**.

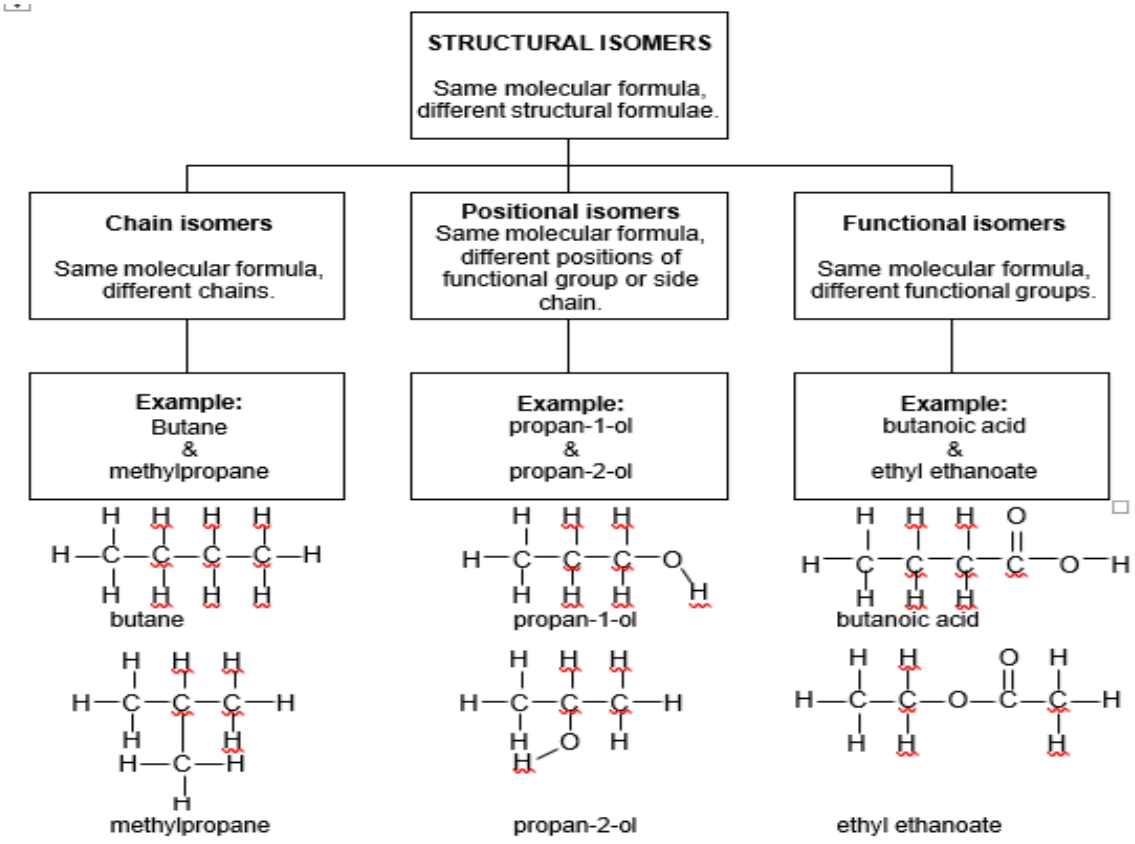
Step 3: Prefix

- **Identify substituents** on the parent chain. Substituents can be *methyl* (one C atom i.e. $–CH_3$) or
  ethyl (2 C atoms i.e. $–CH_2CH_3$).
- **Use numbers on the parent chain to indicate the position of the substituents** on the parent chain.
- **Arrange substituents in alphabetical order** in the IUPAC name (*bromo, chloro, ethyl, methyl*)
- If two or more of the same substituents occur, use di- and tri- in front of the name of the substituent e.g. *dimethyl* or *tribromo*. (*Di-* and *tri* are ignored when arranging substituents in alphabetical order.)
- When there are two (or more) identical groups on the same C atom, the number of the C atom is repeated with commas between the numbers e.g. ***2,4,4-trimethylhexan-3-one***

Compound	Step 1: Suffix	Step 2: Parent name	Step 3: Substituents
	A hydrocarbon with C-C single bonds only, thus an alkane. Ends on **-ane**	Three C atoms in longest chain: -prop- **prop**ane	Methyl group on C2. **2-methyl**propane
	A triple bond between C atoms, thus an alkyne. Ends on **-yne**	Five C atoms in longest chain: -pent- Triple bond after C1. **pent-1-**yne	One methyl group on C4. **4-methyl**pent-1-yne
	An –OH group, thus an alcohol. Ends on –ol	Six C atoms in longest chain. -OH group on C2. **hexan-2-**ol	Methyl group on C4. **4-methyl**hexan-2-ol

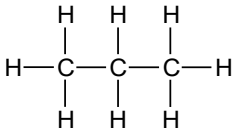
	C-C single bonds and Br groups, thus haloalkane. Name ends on **-ane** with halogen substituents in prefix.	Six C atoms in longest chain. Number from side that results in smallest number for substituents. Br does not get preference when numbering. **hex**ane	Two methyl groups on C2 and C3. Two Br groups on C3 and C5. **3,5-dibromo-2,3-dimethyl**hexane
	A –CHO group, thus an aldehyde. Name ends on −anal	Six C atoms in longest chain. Number from C atom of functional group. **Hex**anal	One substituent is present: a *methyl* group on C4 (the carbonyl C atom is always C1). **4-methylhexanal**

- Final IUPAC names, except those of esters, are written as **one word** with **COMMAS BETWEEN NUMBERS** and **HYPHENS BETWEEN NUMBERS AND WORDS** e.g. *2,4,4-trimethylhexan-3-*
one. IUPAC names of esters and carboxylic acids are written as two words e.g. *ethyl methanoate and pentanoic acid*.



FORMULAE FOR REPRESENTING MOLECULES

Type of formula	Definition	Example	
		Name	Formula
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule.	propane	C_3H_8

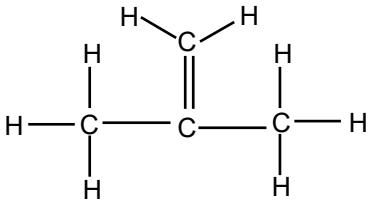
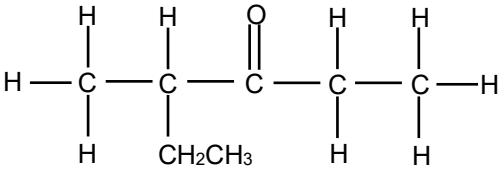
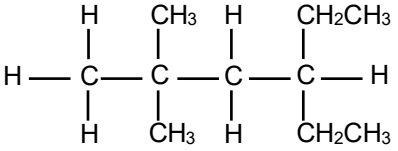
Condensed structural formula	Shows the way in which atoms are bonded together in a molecule but DOES NOT SHOW ALL bond lines.	propane	$CH_3CH_2CH_3$
Structural formula	Shows which atoms are attached to which within the molecule. Atoms are represented by chemical symbols and lines are used to represent ALL the bonds that hold atoms together. Structural formulae usually do NOT depict the actual geometry/shape of molecules.	propane	

NOTE: When drawing **condensed structural formulae,** the following conventions are used:

- All atoms are drawn in, but the **bond lines are usually omitted**
- Atoms are usually drawn next to atoms to which they are bonded
- Brackets are used around similar groups bonded to the same atom

WORKED EXAMPLE

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	2-methylbutanoic acid
C		**D**	
E	But-2-ene		

1.1 Write down the:

1.1.1 NAME of the functional group of compound **B** (1)

Answer: *Carboxyl group* ✓

1.1.2 Homologous series to which compound **C** belongs (1)

Answer: *Ketones* ✓

1.2 Write down the IUPAC name of:

1.2.1 Compound **C** (2)

Answer: *4-methylhexan-3-one OR 4-methyl-3-hexanone* ✓✓

1.2.2 Compound **D** (2)

Answer: *4-ethyl-2,2-dimethylhexane* ✓✓

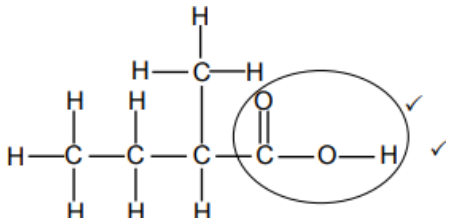
1.3 Write down the NAME or FORMULA of each product formed during the complete combustion of compound **D**. (2)

Answer: *Carbon dioxide/CO_2* ✓ *& water/H_2O* ✓

1.4 Write down the structural formula of:

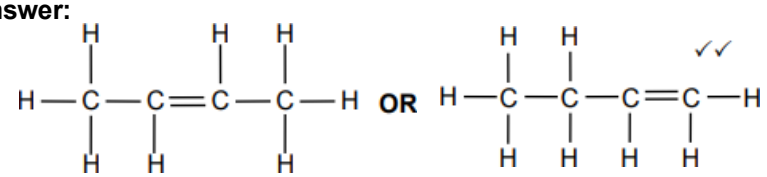
1.4.1 Compound **B** (2)

Answer:



1.4.2 A CHAIN ISOMER of compound **A** (2)

Answer:



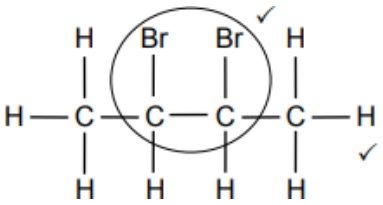
1.5 A laboratory assistant uses bromine water to distinguish between compounds **D** and **E**. She adds bromine water to a sample of each in two different test tubes. She observes that the one compound decolourises the bromine water immediately, whilst the other one only reacts after placing the test tube in direct sunlight. Write

down the:

1.5.1 Letter (**D** or **E**) of the compound that will immediately decolourise the bromine water (1)
Answer: *E* ✓

1.5.2 Name of the type of reaction that takes place in the test tube containing compound **D** (1)
Answer: *Substitution/halogenation/bromination* ✓

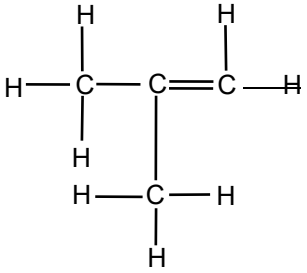
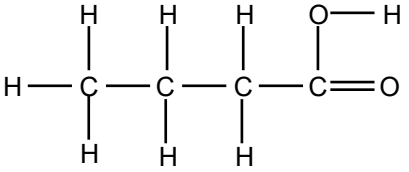
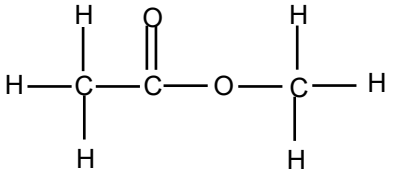
1.5.3 Structural formula of the organic product formed in the test tube containing compound **E** (2)
Answer:



ACTIVITIES

ACTIVITY 1

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C	2,3-dibromo-3-methylpentane	**D**	Ethyl ethanoate
E			
E			

1.1 Write down the LETTER that represents the following:

1.1.1. A hydrocarbon (1)
1.1.2. A functional isomer of compound **B** (1)
1.1.3. A compound which belongs to the same homologous series as compound **D** (1)

1.2 Write down the STRUCTURAL FORMULA of EACH of the following:

1.2.1 Compound **C** (2)

1.2.2 The acid used to prepare compound **D** (2)

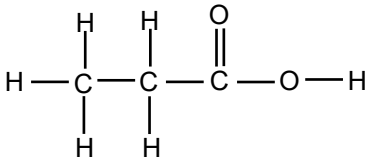
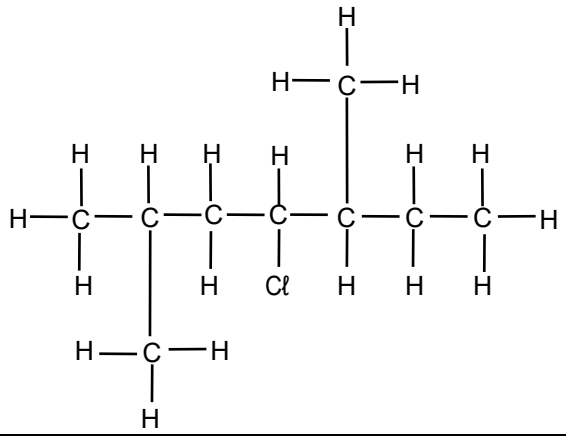
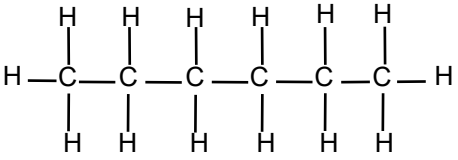
Compound **A** reacts with an unknown reactant, **X**, to form 2-methylpropane

Write down the:

1.2.1 NAME of reactant **X** (1)
1.2.2 Type of reaction that takes place (1)
[10]

ACTIVITY 2

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C	C_4H_8	**D**	$CH_3CH_2COCH_3$
E	$CH_3CH(CH_3)CH_2OH$	**F**	

Use the information in the table (where applicable) to answer the questions that follow.

2.1 Write down the LETTER that represents a compound that:

2.1.1 Is a haloalkane (1)

2.1.2 Has a hydroxyl group as functional group (1)

2.1.3 Belongs to the same homologous series as ethanoic acid (1)

2.2 Write down the:

2.2.1 IUPAC name of compound **B** (3)

2.2.2 IUPAC name of compound **E** (2)

2.2.3 Structural formula of the functional group of compound **D** (1)

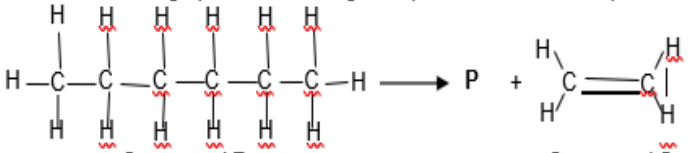
2.3 Compound **C** has CHAIN and POSITIONAL isomers.

2.3.1 Define the term *positional isomer*. (2)

2.3.2 Write down the IUPAC name of each of the TWO positional isomers of compound **C**. (4)

2.3.3 Write down the structural formula of a chain isomer of compound **C**. (2)

2.4 Compound F reacts at high pressure and high temperature to form compounds P and Q as given below.



Compound F Compound Q

Write down the:

2.4.1 Type of reaction that takes place (1)

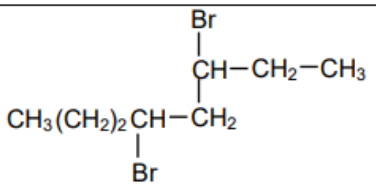
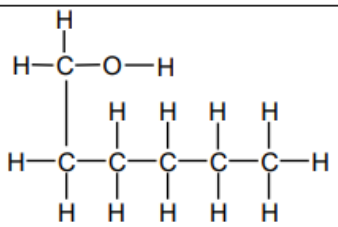
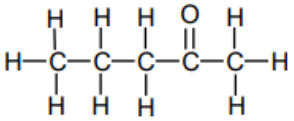
2.4.2 IUPAC name of compound Q (1)

2.4.3 Molecular formula of compound P (1)

[20]

ACTIVITY 3

The letters **A** to **F** in the table below represent six organic compounds.

A	Methanoic acid	**B**	Pentanal
C	$C_{10}H_{22}$	**D**	
E		**F**	

3.1 Write down the LETTER(S) that represent(s) the following:

3.1.1 A ketone (1)

3.1.1 TWO compounds that are FUNCTIONAL ISOMERS (1)

3.1.2 A hydrocarbon (1)

3.2 For compound **D**, write down the:

3.2.1 Homologous series to which it belongs (1)

3.2.2 IUPAC name (3)

3.3 Consider compound **F**. Write down the IUPAC name of its:

3.3.1 POSITIONAL isomer (2)

3.3.2 CHAIN isomer (2)

3.4 During the reaction of compound **A** with compound **E** in the presence of an acid catalyst, two products are formed. For the ORGANIC product formed, write down the:

3.4.1 IUPAC name (2)

3.4.2 STRUCTURAL FORMULA of its FUNCTIONAL GROUP (1)

3.5 Compound **C** ($C_{10}H_{22}$) reacts at high temperatures and pressures to form a three-carbon alkene **P** and an alkane **Q**, as shown below.

$$C_{10}H_{22} \rightarrow \mathbf{P} + \mathbf{Q}$$

Write down the:

3.5.1 Type of reaction that takes place (1)

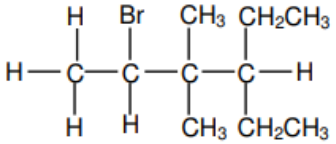
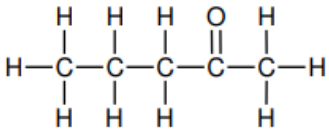
3.5.2 Molecular formula of compound **Q** (2)

3.5.3 STRUCTURAL FORMULA of compound **P** (2)

[19]

ACTIVITY 4

The letters **A** to **E** in the table below represent five organic compounds.

A		**B**	C_xH_y
C		**D**	$CH_3(CH_2)_2CH(OH)CH_2CH_3$
E	$CH_3CH_2CH_2CH_2CH_2CH_2CHCH_2$		

4.1 Write down the LETTER that represents EACH of the following:

4.1.1 A ketone (1)

4.1.2 A hydrocarbon (1)
4.1.3 An alkene (1)

4.2 Write down the:
4.2.1 IUPAC name of compound **A** (3)
4.2.2 STRUCTURAL FORMULA of compound **D** (2)
4.2.3 IUPAC name of the STRAIGHT CHAIN FUNCTIONAL ISOMER of compound **C** (2)

4.3 Compound **B** is a straight chain compound that undergoes the following exothermic reaction:

$2C_xH_y + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$

4.3.1 Besides being exothermic, what type of reaction is represented above? (1)
4.3.2 Determine the MOLECULAR FORMULA of compound **B**. (2)

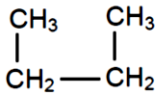
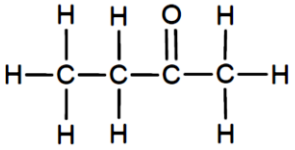
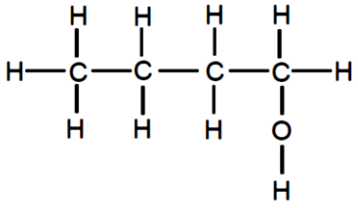
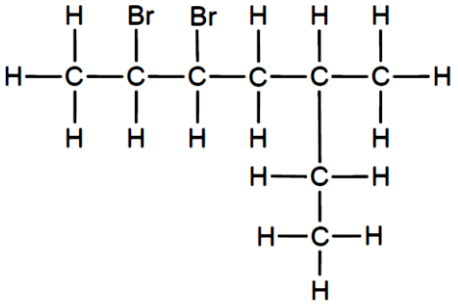
The reaction above takes place in a closed container at a constant temperature higher than 100 °C and at constant pressure.

4.3.3 Calculate the TOTAL VOLUME of gas formed in the container when 50 cm^3 of C_xH_y reacts completely with oxygen. (Answer: 850 cm^3) (3)

[16]

ACTIVITY 5

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C	$CH_3CCCH_2CH_3$	**D**	Butyl propanoate
E		**F**	

5.1 Is compound **C** SATURATED or UNSATURATED? Give a reason for the answer. (2)
5.2 Write down the LETTER that represents each of the following:
5.2.1 An ester (1)
5.2.2 A FUNCTIONAL ISOMER of butanal (1)
5.2.3 A compound with the general formula C_nH_{2n-2} (1)
5.2.4 A compound used as reactant in the preparation of compound **D** (1)
5.3 Write down the STRUCTURAL FORMULA of:
5.3.1 The functional group of compound **C** (1)
5.3.2 Compound **D** (2)
5.3.3 A CHAIN ISOMER of compound **A** (2)
5.4 Write down the:
5.4.1 IUPAC name of compound **F** (3)
5.4.2 Balanced equation, using MOLECULAR FORMULAE, for the complete combustion of compound **A** (3)

[17]

JENN

Training and Consultancy

The path to enlightened education

ORGANIC CHEMISTRY

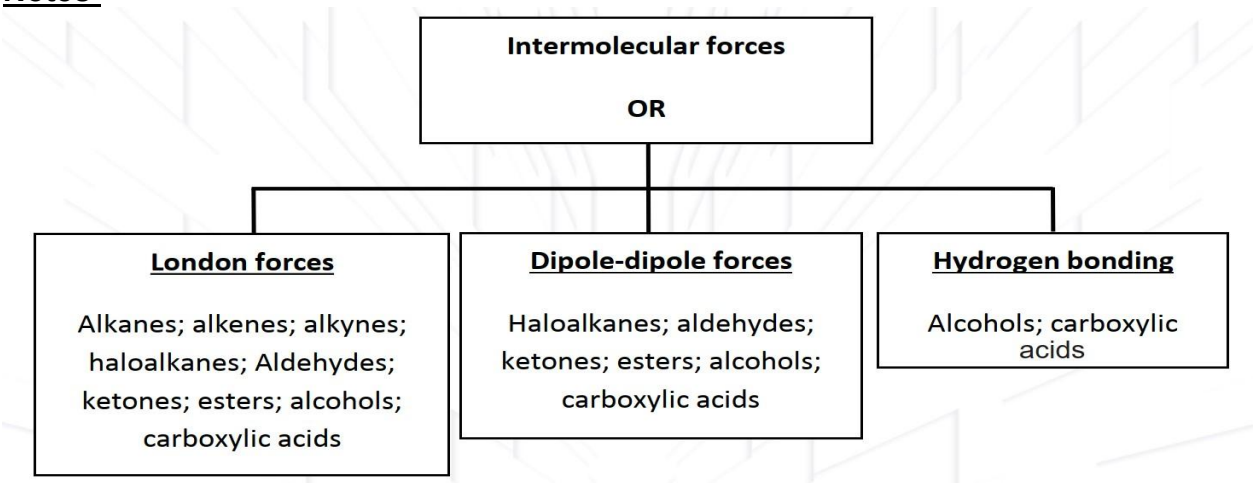
Topic

PHYSICAL PROPERTIES

IMPORTANT TERMS AND DEFINITIONS

TERMS AND DEFINITIONS	
Boiling point	The temperature at which the vapour pressure of a liquid equals atmospheric pressure.
Dipole-dipole force	Intermolecular forces found between polar molecules i.e. molecules in which there is an uneven distribution of charge so that the molecule has a positive and a negative side.
Hydrogen bond	A strong intermolecular force found between molecules in which an H atom is covalently bonded to wither an N, O or F atom.
Intermolecular force	Forces between molecules that determine physical properties of compounds.
London force	A weak intermolecular force between non-polar molecules.
Melting point	The temperature at which the solid and liquid phases of a substance are at equilibrium.
Van der Waals forces	A combined name used for the different types of intermolecular forces.
Vapour pressure	The pressure exerted by a vapour at equilibrium with its liquid in a closed system.
Volatility	How easily a substance will vaporize (turn into a gas or vapour). A volatile substance can be defined as a substance that evaporates readily at normal temperatures and/or one that has a measurable vapour pressure. The term volatile usually applies to liquids.

Notes



Concept	What is it?	Relationship to IMF
Vapour Pressure	The pressure exerted by a vapour in equilibrium with its liquid	Strong IMF – low vapour pressure
Boiling Point	The temperature at which vapour pressure equals external atmospheric pressure	Strong IMF – high boiling point
Melting Point	The temperature at which a solid becomes a liquid	Strong IMF – high melting point

Writing Explanations related to Physical Properties

Comparing compounds in the same homologous

series ■ Identify that they have the same type of IMF.

■ Compare the chain length/molecular size.

■ Relate this to the strength of the IMF (longer chain = stronger forces).

■ Explain the effect on the energy needed to overcome the forces.

■ *Conclude by stating the effect on the physical property.

Techniques for Understanding the Table

Case A: Comparing members of the same homologous series

■ Independent variable – number of carbon atoms

■ Technique – look for a trend in the physical property as the number of carbon atoms increases.

Case B: Comparing different homologous series

■ Independent variable – functional group

■ Technique – identify compounds with a similar number of carbon atoms but different functional groups. Compare their physical properties.

Techniques for Understanding the Table

Case C: Comparing structural isomers

■ Independent variable – branching of the carbon chain

■ Technique – identify isomers. Compare their physical properties.

The Trend

■ Locate the data for the dependent variable in the table and describe the observed trend.

- *Does the B.P. increase or decrease?*
- *Does the vapour pressure increase or decrease?*

■ Justify the trend using Intermolecular Forces.

Worked example

influences the boiling point of organic compounds.

A	$CH_3CH_2CH_2CH_3$
B	$CH_3CH_2CH_2CH_2CH_3$
C	$CH_3CH_2CH_2CH_2CH_2CH_3$

1.1 Which ONE of the compounds (**A**, **B** or **C**) has the highest boiling point? (1)

Answer: *C* ✓

1.2 For this investigation, write down the:

1.2.1 Independent variable (1)

Answer: *Chain length* ✓ *(The independent variable is the "cause".)*

1.2.2 Dependent variable (1)

Answer: *Boiling point* ✓ *(The dependent variable is the "effect".)*

1.3 Write down the name of the type of Van der Waals force that occurs between the molecules of compound **B**. (1)

Answer: *London forces* ✓

1.4 How will the vapour pressure of 2-methylpentane compare to that of compound **C**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

Answer: *Higher than* ✓

The learners now compare the boiling points of compounds **D** and **E**, shown in the table below.

D	$CH_3CH_2CH_2CH_2CH_2OH$
E	$CH_3CH_2CH_2COOH$

1.5 How does the boiling point of compound **D** compare to that of compound **E**? Write down HIGHER
THAN, LOWER THAN or EQUAL TO. Fully explain the answer. (4)

Answer: *Lower than* ✓

Both compounds D and E have hydrogen bonding between molecules. ✓

Compound D has one site for hydrogen bonding whilst compound E has two sites for hydrogen bonding ***OR*** *compound E can form dimers.* ✓

More energy needed to overcome intermolecular forces in compound E. ✓

[9]

Activities

ACTIVITY 1

1.1 The melting points of some organic compounds are given in the table below.

COMPOUND	IUPAC NAME	MELTING POINTS (°C)
A	Propanone	—95,4
B	Butanone	—86,9
C	Pentan-2-one	—77,8
D	3-methylbutanone	—92

1.1.1 To which homologous series do the above compounds belong? (1)

The melting points of compounds **A**, **B** and **C** are compared.

1.1.2 Write down the controlled variable for this comparison. (1)
The melting points of compounds **C** and **D** are compared.
1.1.3 Fully explain the difference in the melting points of these two compounds. (4)

1.2 The table below shows the results obtained from an experiment to determine the vapour pressure of different STRAIGHT CHAIN primary alcohols at 300 K.

ALCOHOL	VAPOUR PRESSURE (kPa)
CH_3OH	16,8
C_2H_5OH	7,88
C_3H_7OH	2,8
C_4H_9OH	0,91
$C_5H_{11}OH$	0,88
$C_6H_{13}OH$	0,124

1.2.1 Define the term *vapour pressure*. (2)
1.2.2 Write down a suitable conclusion for this investigation. (2)
1.2.3 Write down the IUPAC name of the alcohol with the HIGHEST boiling point. (3)
1.2.4 The experiment is now repeated at 320 K.
Will the vapour pressure of each compound INCREASE, DECREASE or REMAIN THE SAME? (1)
[14]

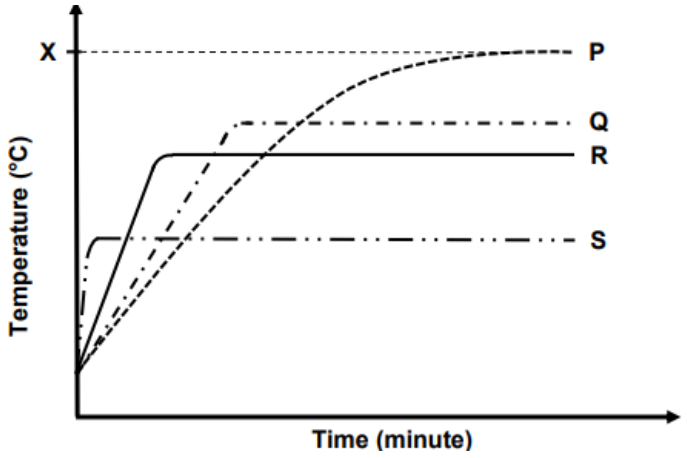
ACTIVITY 2

Learners investigate the boiling points of the four organic compounds given below.

ORGANIC COMPOUND	MOLECULAR MASS ($g \cdot mol^{-1}$)
Butanone	72
Butan-1-ol	74
Propanoic acid	74
2-methypropan-1-ol	74

2.1 Define the term boiling point. (2)
2.2 Which compound, butan-1-ol or 2-methylpropan-1-ol, will have the higher boiling point? Fully explain the answer. (4)

The curves **P**, **Q**, **R** and **S** below were obtained from the results of the investigation.**X** represents a



specific temperature.

2.3 Which physical property is represented by temperature X? (1)
2.4 Which curve (**P**, **Q**, **R** or **S**) represents:
2.4.1.1 Butanone (1)
2.4.1.2 Propanoic acid (1)
2.4.1.3 2-methylpropan-1-ol (1)
2.4.2 Give a reason for the answer to QUESTION 19.4.2. (1)
[11]

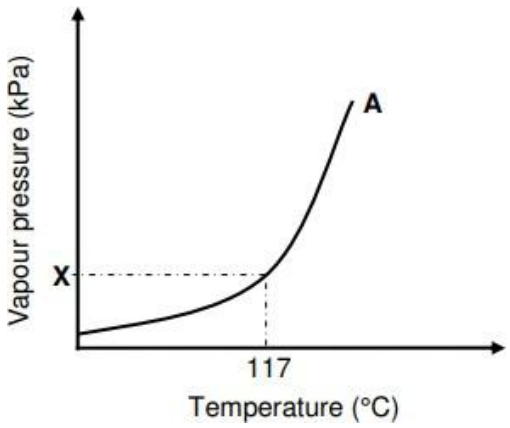
ACTIVITY 3

Compounds **A**, **B** and **C** are used to investigate a factor which influences the boiling points of organic compounds. The results of the investigation are given in the table below.

COMPOUND		BOILING POINT (°C)
A	Butan-1-ol	117
B	Butan-2-ol	100
C	2-methylpropan-2-ol	82

3.1 Is this a fair investigation? Choose from YES or NO. (1)
3.2 Give a reason for the answer to QUESTION 15.1. (1)
3.3 Fully explain the difference in the boiling points of compounds **B** and **C**. (3)
3.4 Define the term *positional isomer*. (2)
3.5 From compounds **A**, **B** and **C**, choose the letter(s) that represent(s) EACH of the following:
3.5.1 Positional isomers (1)
3.5.2 A tertiary alcohol
Give a reason for the answer. (2)

3.6 The graph represents the relationship between vapour pressure and temperature for compound **A** (butan-1-ol).



3.6.1 Write down the value of **X**. (1)
3.6.2 Redraw the graph above in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained for compound **C**. Clearly label the curves **A** and **C**.
Indicate the relevant boiling point for compound **C** on the graph. (2)
[13]

ACTIVITY 4

The vapour pressures of different organic compounds are determined at 20 °C. The vapour pressures of compounds **A**, **B** and **C** are NOT shown in the table.

COMPOUND	IUPAC NAME	MOLAR MASS ($g \cdot mol^{-1}$)	VAPOUR PRESSURE (kPa) AT 20 °C
A	Pentane	72	
B	2-methylbutane	72	
C	2,2-dimethylpropane	72	
D	Propanoic acid	74	0,32
E	Butanal	72	12,2

4.1 Define the term *vapour pressure.* (2)

4.2 The vapour pressures of compounds **A**, **B** and **C** are given in random order below.

79 kPa	146 kPa	58 Pa

4.2.1 Write down the vapour pressure of compound **C**. (1)

4.2.2 Fully explain your answer to QUESTION 3.2.1. (3)

4.3 Compounds **D** and **E** are compared.

4.3.1 Which compound has the lower boiling point? (1)
4.3.2 Fully explain the difference in the vapour pressures between

compounds **D** and **E**. (4)

[11]

JENN

Training and Consultancy

The path to enlightened education

ORGANIC CHEMISTRY

Topic

ORGANIC REACTIONS

NOTES

SUMMARY OF ORGANIC REACTIONS				
	Reaction name	**Reactants**	**Reaction conditions**	**Products**
Substitution	Halogenation	alkane + halogen	hf/Δ	haloalkane + hydrogenhalide
	Hydrolysis	haloalkane + base (NaOH/KOH)	• DILUTE strong base • Mild heat	alcohol + halide salt
		haloalkane + water	• Add water • Mild heat	alcohol + hydrogen halide
	Substitution	alcohol + hydrogen halide	No water	haloalkane + water
Addition	Hydration	alkene + water	Concentrated H_2SO_4	alcohol
	Hydrogenation	alkene + hydrogen	Pt, Pd, Ni; dissolved in non-polar solvent	alkane
	Halogenation	alkene + halogen	Room temperature and pressure (no catalyst needed)	haloalkane
	Hydrohalogenation	alkene + hydrogen halide	no water	haloalkane
Elimination	Cracking	alkanes	High temperature OR Catalyst	alkene + hydrogen/ alkane +alkene OR alkane + alkene
	Dehydrohalogenation	haloalkane + base (NaOH/KOH)	• CONCENTRATED strong base • Heat	alkene + salt + water
	Dehydration	alcohol	• Concentrated H_2SO_4 • Heat	alkane + water

Essential Skills

- Represent reactions: Write balanced chemical equations using both structural and molecular formulae.
- Identify reactants and product: Given the name or structure of a reactant, determine the product(s) and vice versa.
- Recall the conditions: State specific conditions.
- Use terminology: Use key terms like “addition”, “elimination”, and “substitution” accurately in explanations.

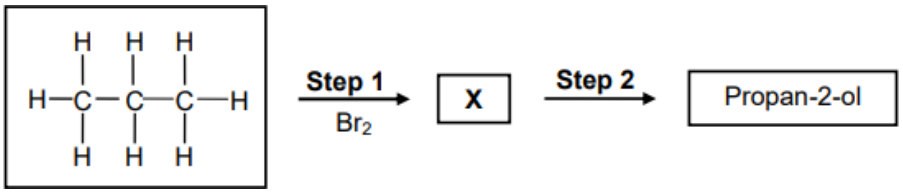
Approach to Flow Diagrams

1. Analyze the starting material:
   - Identify the functional group
   - Identify the structure
2. Analyze each step individually:
   - Look at the arrow (info on the arrow)
   - Identify the reagent (substance added to the reaction)
   - Identify the condition (e.g. *Pt, Ni*)

EXAMPLES

EXAMPLE

1.1 The flow diagram below shows the conversion of propane to propan-2-ol.



1.1.1. State ONE reaction condition for **Step 1**. (1)

Answer: *Heat/sunlight* ✓

1.1.2. Write down the NAME or FORMULA of the INORGANIC product formed in **Step 1**. (1)

Answer: *HBr/hydrogen bromide* ✓

1.1.3. Name the TYPE of substitution reaction represented by **Step 2**. (1)

2.1.1 Write down the NAME or FORMULA of the INORGANIC reagent needed in **Step 2**. (1)

Answer: *H_2O/water* ✓

OR

NaOH/KOH/LiOH/sodium hydroxide/potassium hydroxide/lithium hydroxide

2.1.2 Write down the IUPAC name of compound **X**. (2)

Answer: *2-bromo*✓*propane* ✓

2.1 Ethane can be prepared from chloroethane ($CH_3CH_2C\ell$) by a TWO-STEP process. You are supplied with the following chemicals:

H_2	$HC\ell$	$C\ell_2$	H_2O	Pt	ethanol	concentrated H_2SO_4	concentrated NaOH

Select chemicals in the table above that can be used for this preparation. Using CONDENSED structural formulae, write down a balanced equation for EACH reaction. Indicate the reaction conditions for EACH reaction. (8)

Answer: Ethanol ✓

$CH_3CH_2C\ell$ + conc. NaOH ✓ $\xrightarrow{\Delta}$ CH_2CH_2 ✓ + $NaC\ell$ ✓ + H_2O ✓

$CH_2CH_2 + H_2$ ✓ ⟶

Marking criteria

ACTIVITES

ACTIVITY 1

Butane (C_4H_{10}) is produced in industry by the THERMAL cracking of long-chain hydrocarbon molecules, as shown in the equation below. **X** represents an organic compound that is produced.

$$C_{10}H_{22} \rightarrow \mathbf{X} + C_4H_{10}$$

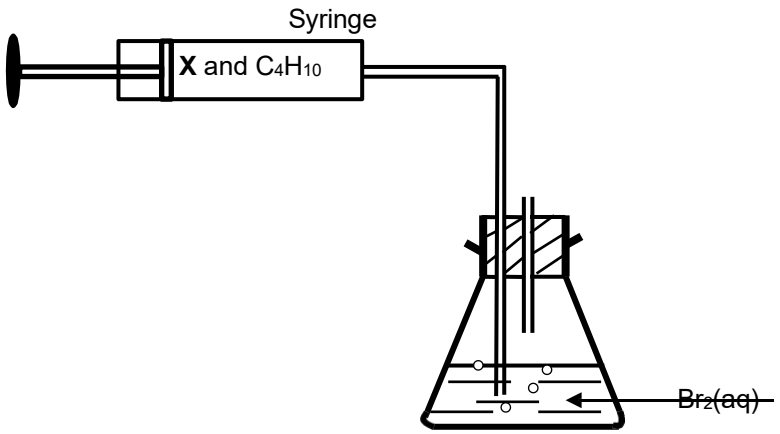
1.1 Write down:

1.1.1 ONE condition required for THERMAL cracking to take place (1)

1.1.2 The molecular formula of compound **X** (1)

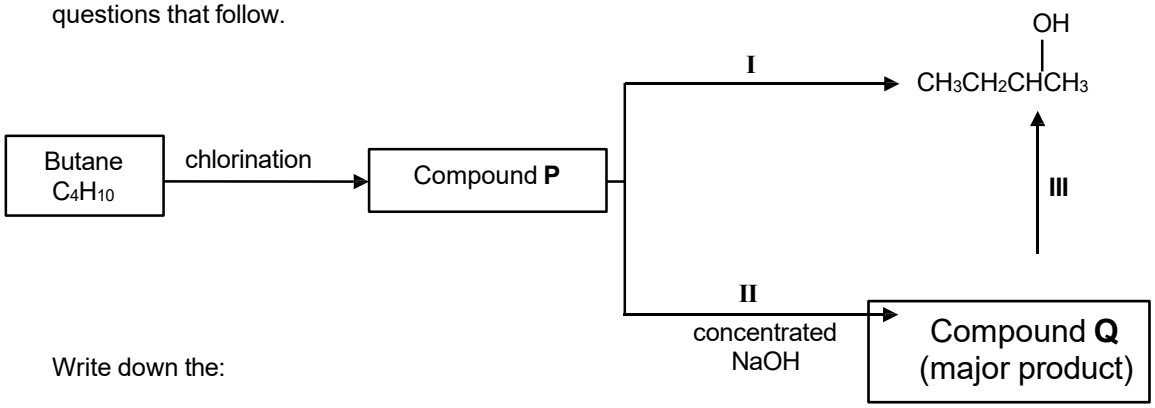
1.1.3 The homologous series to which compound **X** belongs (1)

1.2 A mixture of the two gases, compound **X** and butane, is bubbled through bromine water, $Br_2(aq)$, in a conical flask, as illustrated. THE REACTION IS CARRIED OUT IN A DARKENED ROOM.



The colour of the bromine water changes from reddish brown to colourless when the mixture of the two gases is bubbled through it. Which ONE of the gases (**X** or BUTANE) decolorizes the bromine Water? Explain the answer.
(4)

1.3 Study the flow diagram below, which represents various organic reactions, and answer the questions that follow.



Write down the:

1.3.1 IUPAC name of compound **P** (2)

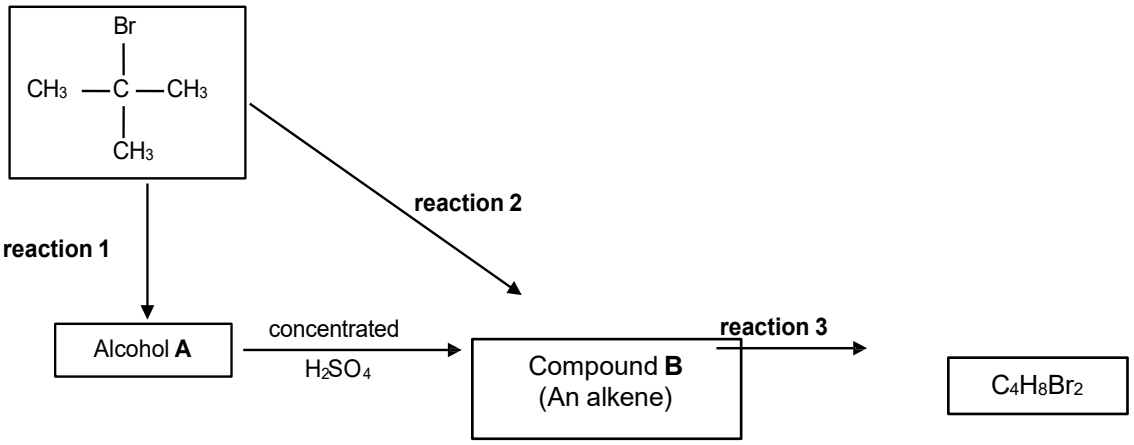
1.3.2 Type of reaction labelled **I**

1.3.3 Structural formula of compound **Q** (2)

1.3.4 The type of addition reaction represented by reaction III (1)

[13]

ACTIVITY 2



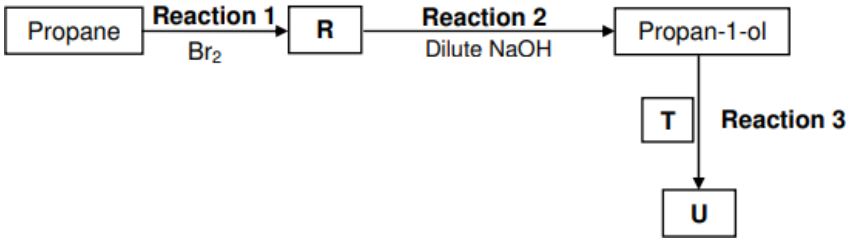
Write down the:

2.1 Type of reaction represented by **reaction 1** (1)
2.2 NAME or FORMULA of the inorganic reactant needed for **reaction 1** (1)
2.3 Type of alcohol (PRIMARY, SECONDARY or TERTIARY) of which alcohol **A** is an example (1)
2.4 Type of reaction represented by **reaction 2** (1)
2.5 IUPAC name of compound **B** (2)
2.6 Type of addition reaction represented by **reaction 3** (1)
2.7 Balanced equation for **reaction 3** using structural formulae (4)

[11]

ACTIVITY 3

3.1 The flow diagram below shows various organic reactions using propane as starting reactant. **R**, **T** and **U** represent different organic compounds. Compound **T** is a CARBOXYLIC ACID, and compound **U** is a FUNCTIONAL ISOMER of pentanoic acid.



Write down the NAME of the type of reaction represented by:

3.1.1 **Reaction 1** (1)
3.1.2 **Reaction 2** (1)

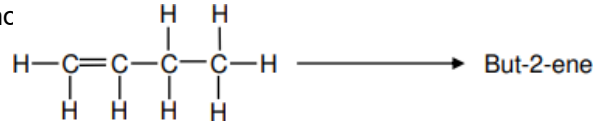
Consider **reaction 1** and **reaction 2**.

3.1.3 Write down the IUPAC name of compound **R**. (2)

Reaction 3 takes place in the presence of a catalyst and heat. Write down the:

3.1.4 NAME or FORMULA of the catalyst (1)
3.1.5 IUPAC name of compound **T** (2)
3.1.6 STRUCTURAL FORMULA of compound **U** (2)

3.2 A laboratory technician wants to prepare but-2-ene using but-1-ene as starting reagent, as shc



The following chemicals are available in the laboratory:

concentrated H_2SO_4	H_2O	concentrated NaOH

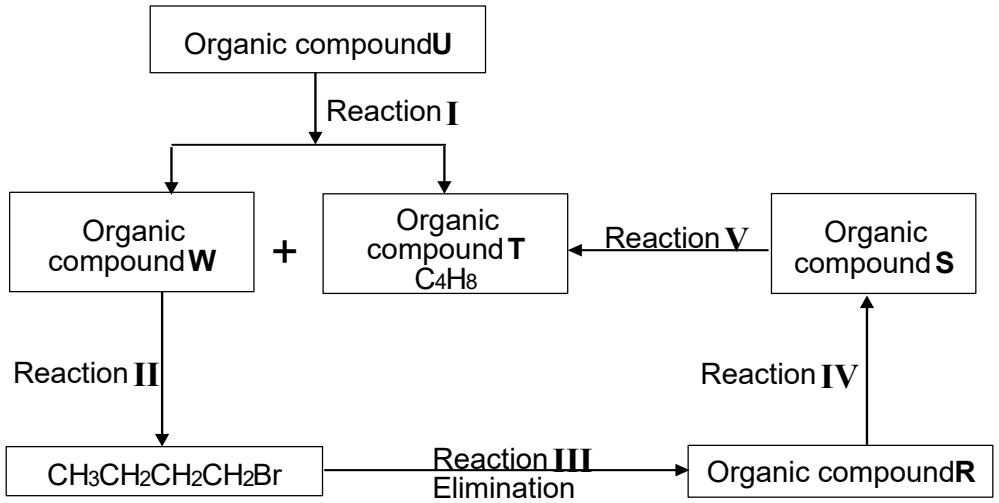
Select the chemicals required to design this preparation from the list above. For EACH step of the preparation, write down the balanced equation, using STRUCTURAL FORMULAE for all organic compounds. Indicate the chemicals needed in each step. (6)

[15]

ACTIVITY 4

Study the flow diagram below.

Reaction **I** is a CRACKING REACTION forming two organic compounds, **W** and **T**, as the ONLY products.



4.1 Define the term *cracking reaction*. (2)

4.2 Is the product in reaction **II** a PRIMARY, SECONDARY or TERTIARY haloalkane? Give a reason for the answer. (2)

4.3 Write down the:

4.3.1 STRUCTURAL FORMULA of compound **W** (3)

4.3.2 MOLECULAR formula of compound **U** (1)

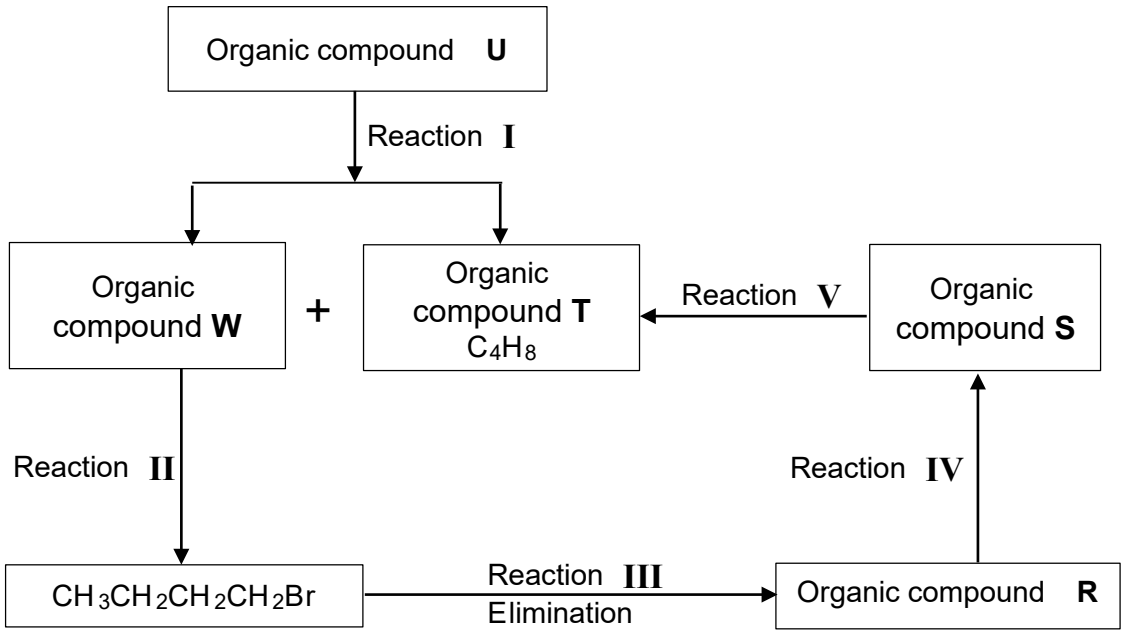
4.4 For reaction **II**, write down:

4.4.1 The NAME or FORMULA of the inorganic reactant (1)

4.4.2 The type of reaction (Choose from SUBSTITUTION, ADDITION or ELIMINATION.) (1)

4.4.3 ONE reaction condition (1)

The flow diagram on page 9 is redrawn below for easy reference



4.5 Write down the TYPE of elimination in reaction **III**. (1)

4.6 Compounds **R** and **T** are positional isomers.

The inorganic reagents shown below are available for reactions **IV** and **V**.

Br_2	H_2SO_4(conc.)	NaOH(conc.)	HBr	H_2

Write down:

4.6 The balanced equation for reaction **IV**, using STRUCTURAL FORMULAE and the correct inorganic reagent shown above (5)

4.7 The balanced equation for reaction **V**, using STRUCTURAL formulae and the correct reagent shown above (3)

4.8 The IUPAC name of compound **T** (2)

[22]

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