SECONDARY SCHOOL IMPROVEMENT PROGRAMME (SSIP) 2019

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

SUBJECT: PHYSICAL SCIENCE

LEARNER GUIDE

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2019

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GRADE 12

SUBJECT: PHYSICAL SCIENCE

ORGANIC CHEMISTRY

SESSION 1

GAUTENG PROVINCE
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ORGANIC MOLECULES

1. ALL DEFINITIONS IN THIS TOPIC NEEDS TO BE GIVEN TO LEARNERS AT THE BEGINNING OF THE TOPIC AND SHOULD BE LEARNED
    - HOMOLOGOUS SERIES
    - FUNCTIONAL GROUP
    - ISOMERS: STRUCTURAL ISOMER,CHAIN ISOMERS, POSITIONAL ISOMERS

2. ISOMERISM NEEDS TO BE TAUGHT IN DETAIL AND APPLIED TO ALL THE VARIOUS HOMOLOGOUS SERIES

3. ALL FORMULAE NEED TO BE TAUGHT:
    - MOLECULAR
    - STRUCTURAL
    - CONDENSED STRUCTURAL
    - CONDENSED STRUCTURES

4. REPRESENTATION OF ORGANIC MOLECULES IN ALL FORMS
    - STRUCTURAL
    - CONDENSED STRUCTURAL FORMULA

5. USE EASY WAYS TO HELP LEARNERS DRAW STRUCTURAL FORMULAE **E.G**. **CARBOXYLIC ACIDS AND ALDEHYDES** ARE EASY TO DRAW IF YOU START WITH A FUNCTIONAL GROUP AND MOVE BACKWARD

6. AT THE END OF THE ORGANIC COMPUNDS TOPIC,THE FOLLOWING ARE EXAMINABLE:
    - NAMING AND IDENTIFYING ORGANIC MOLECULES
    - PROPERTIESF ORGANIC MOLECULES -**ONLY BOILING POINT,MELTING POINT AND VAPOUR PRESSURE ARE EXAMINABLE**
    - ORGANIC REACTIONS

7. NAMING OF ORGANIC MOLECULES-ALL RULES NEED TO BE TAUGHT AT THE BEGINNING OF THE TOPIC SO THAT LEARNERS ARE ABLE TO APPLYTHEM IN NAMING ORGANIC MOLECULES

RULES OF NAMING ORGANIC MOLECULES:

1. **Identify the longest carbon chain**. This will serve as the structure for the compound. Choose the chain in such a way that all functional groups are part of the main structure or chain. Number the chain in such a way that functional groups are attached to the carbon with the lowest possible number. In the absence of a definitive functional group side chains will have to have the lowest number.

2. **Begin the IUPAC name by starting at the back**. Write down the suffix of the series to which the main chain belongs. This will be decided by the functional group contained in the main chain. If there is a double bond the suffix would be –ene. Specify in front of the completed word on which carbon a double- or triple bond starts.

3. In cases where there is more than one double- or triple bond **the appropriate prefix should be used**: e.g. –diene; -triene; -diyne; -triyne. In front of the completed word specify on which carbon atoms the double or triple bonds begin. If there are three double bonds you should have three specifying numbers, one for each starting point of each bond.

4. **Count the amount of carbons in the main chain** and use this to determine the prefix of the name. For one to ten carbons use the appropriate prefix from the following list: meth-; eth-; prop-; but-; pent-; hex-; hept-; oct-; non-; dec-.

5. **Side chains are called alkyl groups**. Name the side chains by counting only the carbons in the specific side chain and use this to determine the prefix for the side chain. In front of each name of a side chain write the number of the carbon in the main chain to which it is bonded.

6. When there is **more than one of the same side chains** group them together by using prefixes di- tri- and tetra-. In front of the side chain's name use the carbon numbers to which each chain is bonded.

7. **When halogen atoms are present** in the molecule name them by using the terms chloro- bromo- .when there are more than one of the same atom use the prefixes di-; tri- or tetra-again specify onto which carbon in the main chain it is bonded by adding the number of main chain carbon in front of the name.

8. **When there are –OH groups use the suffix –nol.** Again specify on which carbon the –OH is bonded in the middle of the name by writing down the

number of that carbon. When there are more than one –OH group use –diol; -triol; etc.

9. **Carboxylic acids are named by adding the suffix –oic acid**. The prefixes are again determined by the amount of carbon atoms in the chain as explained in step 4. If there are any side chains, the main chain should be numbered starting at the functional group.

10. **Esters are named using a side branch** as well as the main chain as the –**noate**. The chain is divided by the presence of an oxygen atom in the chain. The portion of the molecule containing both oxygen atoms is the main chain and the other portion serves as the side chain.

NOTE THE FOLLOWING:

- ALL HYDROCARBONS WILL UNDERGO COMBUSTION/OXIDATION
- ALL SATURATED ORGANIC MOLECULES (**ALKANES,ALCOHOLS,HALOALKANES)** WILL UNDERGO SUBSTIUTION AND ELIMINATION
- UNSATURATED HYDROCARBONS WILL UNDERGO ADDITION REACTIONS (HYDROGENATION,HYDRATION,HALOGENATION AN HYDROHALOGENATION) NB****ADDITION REACTIONS OF ALKYNES ARE NOT EXAMINABLE***
- **ESTERIFICATION/CONDENSATION -** REACTION BETWEEN A PRIMARY ALCOHOLS AND CARBOXYLIC ACIDS.WRITE THE ALCOHOL AS IS AND THE CARBOXYLIC ACID FROM THE RIGHT TO THE LEFT

MULTIPLE CHOICE QUESTIONS

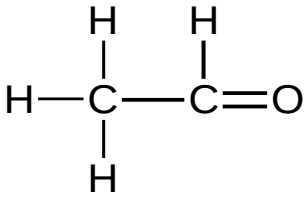
QUESTION 1

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 $C_nH_{2n+1}OH$ is the GENERAL FORMULA for …

A Alkanes.
B
C Aldehydes.
D
Alcohols.
Alkenes. (2)

1.2 Consider the structural formula of an organic compound below.



Which ONE of the following is the correct IUPAC name of this compound?

A Ethanone

B Ethene.

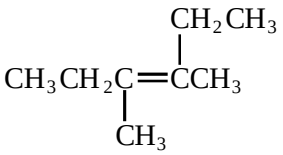
C Ethanol

D Ethanal. (2)

1.3 Which ONE of the following reaction types can be used to prepare ETHENE from ETHANE?

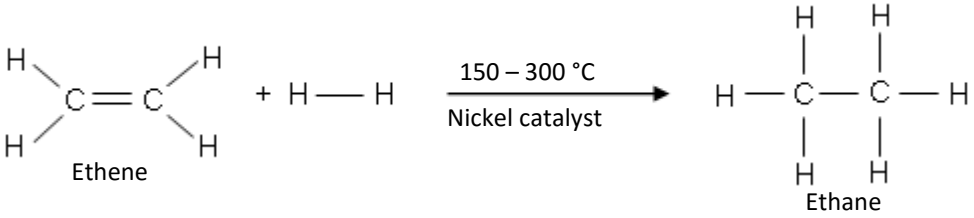
A Hydrogenation
B Substitution
C Dehydrogenation
D Addition

(2)

1.4 The correct systematic name for  is

A 2,3-diethylbut-2-ene
B 2-ethyl-3-methylpent-2-ene
C 4-ethyl-3-methylpent-3-ene
D 3,4-dimethylhex-3-ene (2)

1.5 The reaction below represents

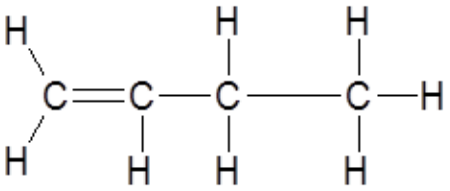
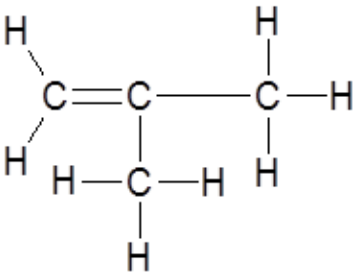
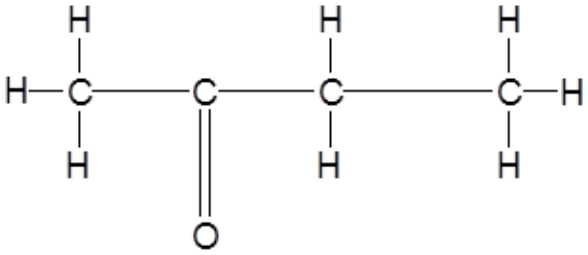
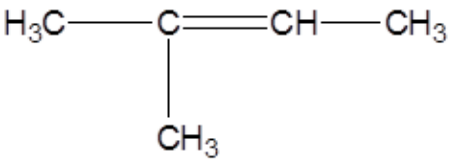


A halogenation
B hydration
C hydrolysis
D hydrogenation (2)

[10]

QUESTION 2

Consider the organic compounds represented by the letters **A** to **G** in the table below:

A 	**B** 	
C But-2-ene	**D** $CH_3CH_2CH_2COOH$	**E** Methyl propanoate
F 	**G** 	

2.1 Define the term **hydrocarbon.** (2)

2.2 Write down the LETTER that represents...

2.2.1 a chain isomer of compound A. (1)

2.2.2 a positional isomer of compound A. (1)

2.2.3 a functional isomer of compound D. (1)

2.3 Define the term **structural isomer**. (2)

2.4 Write down the IUPAC name of compound B. (2)

2.5 Write down the molecular formula of compound C. (1)

2.6 Write down the structural formula of compound **E**. (2)

2.7 Write down the structural formula for the functional group of compound C. (1)

QUESTION 3

A learner conducts a scientific investigation to compare the boiling points of organic compounds belonging to different homologous series. Propan-1-ol, ethanoic acid and propanal are used for the investigation. His results are shown in the table below.

Compound	**Boiling point c**
Compound A	48
Compound B	97
Compound C	118

3.1 For this investigation, name the …

3.1.1 independent variable. (1)

3.1.2 dependent variable. (1)

3.2 Will the vapour pressure of propanal be LOWER or HIGHER than the vapour pressure of propan-1-ol? Explain your answer by referring to the type of INTERMOLECULAR FORCES present and ENERGY. (4)

3.3 Identify:

3.3.1 Compound A (1)

3.3.2 Compound B (1)

3.3.3 Compound C (1)

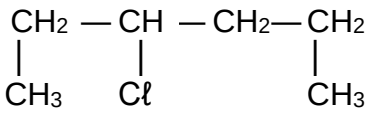
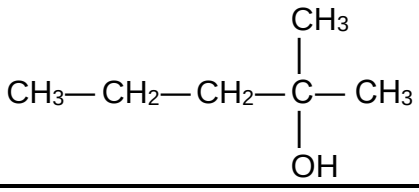
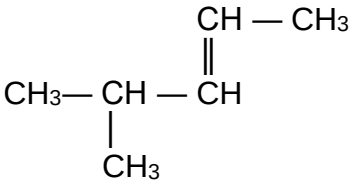
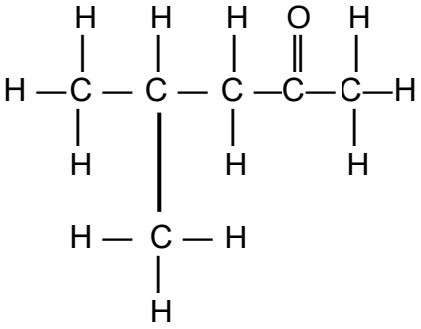
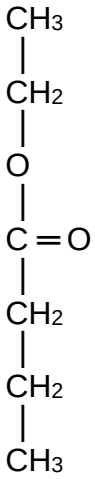
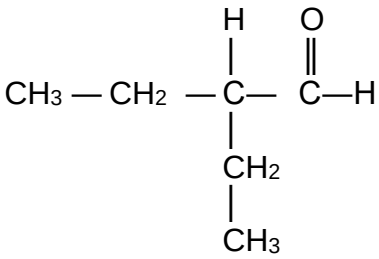
3.4 Will the boiling point of butan-1-ol be HIGHER or LOWER than the boiling point (2)

of propan-1-ol? Explain the answer referring to the INTERMOLECULAR FORCES.

[11]

QUESTION 4

The letters **A** to **H** represent eight organic compounds.

A		**B**	
C		**D**	4-methylpentanoic acid
E		**F**	
G	Pentan-2-ol		
H			

4.1 Write down the letter(s) that represent(s) each of the following:
(A compound may be used more than once.)

4.1.1 An aldehyde (1)

4.1.2 A compound containing the carbonyl group as a functional group (1)

4.1.3 A tertiary alcohol (1)

4.2 Write down:

4.2.1 the IUPAC name of compound **A** (2)

4.2.2 the NAME of the functional group of compound **C** (1)

4.2.3 the STRUCTURAL FORMULA of the substituent (side chain) of compound **D** (2)

4.2.4 ONE use of compound **F** (1)

4.2.5 the STRUCTURAL FORMULA of compound **D** (2)

QUESTION 5

Three hydrocarbons (A, B and C) with a molecular formula C_5H_{12} are used to investigate the effect of **branched chains** on the **boiling point** of hydrocarbons. The results obtained are given in the table below.

HYDROCARBON	BOILING POINT (ºC)
A	36
B	28
C	10

(2)

5.1 Are these hydrocarbons saturated or unsaturated? Explain the answer. (1)

5.2 ONE of the hydrocarbons (**A, B** or **C**) has an unbranched chain.

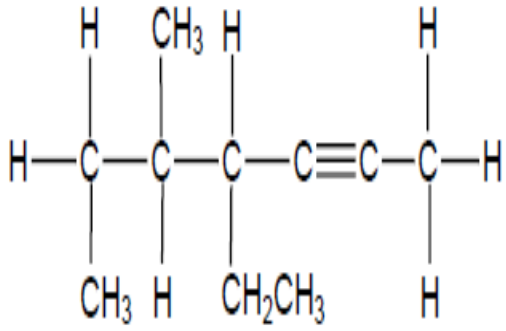
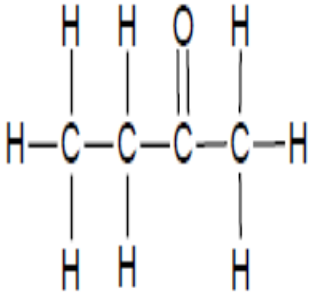
5.2.1 Write down the letter (**A, B** or **C**) that represents this hydrocarbon. (2)

5.2.2 Give a reason why the above-mentioned compounds are considered to be **chain isomers.** (3)

5.3 Explain why hydrocarbon **C** has the lowest boiling point. In the explanation refer to the MOLECULAR STRUCTURE of compound **C**, INTERMOLECULAR FORCES and the ENERGY required.

QUESTION 6

The letters A to D in the table below represent four organic compounds.

A		**B**	
C	CH_3CH_2CHO	**D**	Butane

Use the information in the table to answer the questions that follow.

6.1 Write down the:

6.1.1 Letter that represents a ketone (1)

6.1.2 Structural formula of the functional group of compound C (1)

6.1.3 General formula of the homologous series to which compound A belongs (1)

6.1.4 IUPAC name of compound A (3)

6.1.5 IUPAC name of compound B (2)

6.2 Compound D is a gas used in cigarette lighters.

6.2.1 To which homologous series does compound D belong? (1)

6.2.2 Write down the STRUCTURAL FORMULA and IUPAC NAME of a structural isomer of compound D. (4)

6.2.3 Is the isomer in QUESTION 5.2.2 a CHAIN, POSITIONAL or FUNCTIONAL isomer? (1)

6.3 Compound D reacts with bromine (Br_2) to form 2-bromobutane.

Write down the name of the:

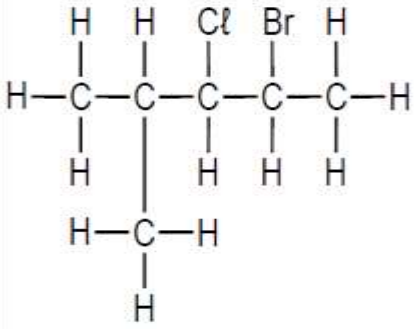
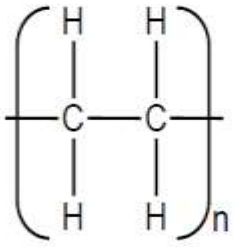
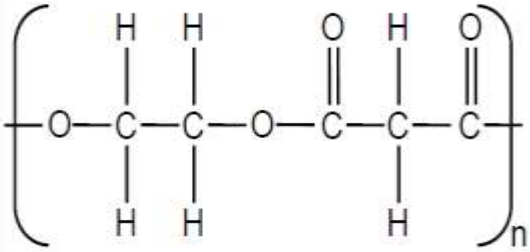
6.3.1 Homologous series to which 2-bromobutane belongs (1)

6.3.2 Type of reaction that takes place (1)

[16]

QUESTION 7

7.1 Consider the organic compounds represented by the letters **A** to **F** in the table below.

A	2,2,4-trimethylhexane	**B**	$CH_3CH_2CH_2CH_2CHO$
C		**D**	
E		**F**	Pentan-2-one

Write down the LETTER that represents the following:

7.1.1 An aldehyde (1)

7.1.2 A condensation polymer (1)

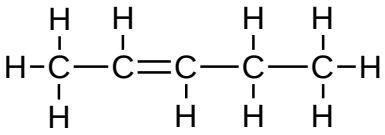
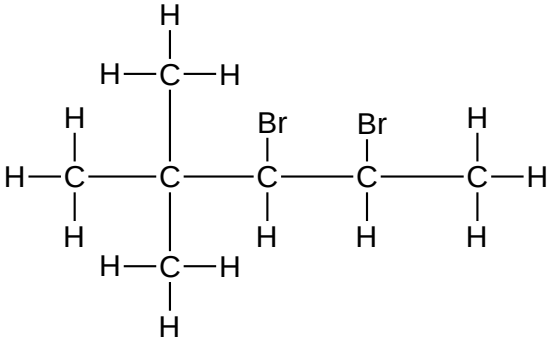
7.1.3 A compound which has a carbonyl group bonded to two carbon atoms as its functional group (1)

7.2 Write down the IUPAC name of:
7.2.1 Compound C (3)
7.2.2 The monomer of compound D (1)
7.3 Write down the structural formula of:
7.3.1 Compound A (2)
7.3.2 Compound F (2)
7.4 The table contains compounds which are functional isomers.
7.4.1 Define the term functional isomer. (2)
7.4.2 Write down the LETTERS that represent two compounds that are functional isomers. (1)

[14]

QUESTION 8

The letters **P** to **U** in the table below represent six organic compounds.

P		**Q**	Methylpropanoate
R	3-Methylbutan-2-ol	**S**	$CH_3CH_2CH_2CO_2H$
T		**U**	$CH_3CH_2CH_2COCH_2CH_3$

8.1 Write down the LETTER(S) that represent(s) the following:
(A compound/ letter may be used more than once)
8.1.1 A ketone. (1)
8.1.2 A carboxylic acid (1)
8.1.3 A compound with the general formula C_nH_{2n} (1)
8.1.4 Two compoounds that are FUNCTIONAL ISOMERS. (1)
8.2 Write down the IUPAC name of compound:

8.2.1 **T** (3)

8.2.2 **U** (2)

8.3 Write down the STRUCTURAL FORMULA of compound:

8.3.1 **Q** (2)

8.3.2 **R** (2)

8.4 Compound **R** is a secondary alcohol. Explain the validity of this statement. (1)

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SECONDARY SCHOOL IMPROVEMENT PROGRAMME (SSIP) 2019

GRADE 12

SUBJECT: PHYSICAL SCIENCE

ORGANIC REACTIONS

SESSION 2

GAUTENG PROVINCE
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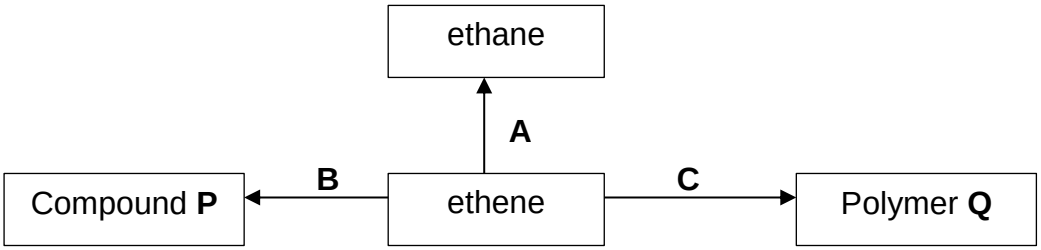
NOTE THE FOLLOWING:

- ALL HYDROCARBONS WILL UNDERGO COMBUSTION/OXIDATION
- ALL SATURATED ORGANIC MOLECULES (**ALKANES,ALCOHOLS,HALOALKANES)** WILL UNDERGO SUBSTIUTION AND ELIMINATION
- UNSATURATED HYDROCARBONS WILL UNDERGO ADDITION REACTIONS (HYDROGENATION,HYDRATION,HALOGENATION AN HYDROHALOGENATION) NB*****ADDITION REACTIONS OF ALKYNES ARE NOT EXAMINABLE***
- **ESTERIFICATION/CONDENSATION -** REACTION BETWEEN A PRIMARY ALCOHOLS AND CARBOXYLIC ACIDS.WRITE THE ALCOHOL AS IS AND THE CARBOXYLIC ACID FROM THE RIGHT TO THE LEFT

QUESTION 1

The flow diagram below shows how some organic compounds can be prepared from ethene. A, B and C represent different organic reactions.



1.1 For reaction **A**, write down:

1.1.1	The FORMULA or NAME of the other reagent needed	(1)
1.1.2	The type of addition reaction	(1)
1.1.3	The FORMULA or NAME of the catalyst used	(1)
1.1.4	One use of the reaction in the FOOD industry.	(1)

1.2 Reaction **B** takes place when ethene reacts with hydrogen bromide (HBr).
For this reaction, write down the:

(1)

1.2.1	Name of the reaction that takes place	(4)
1.2.2	Balanced equation using structural formulae	
1.2.3	Name of the homologous series to which compound **P** belongs	(1)

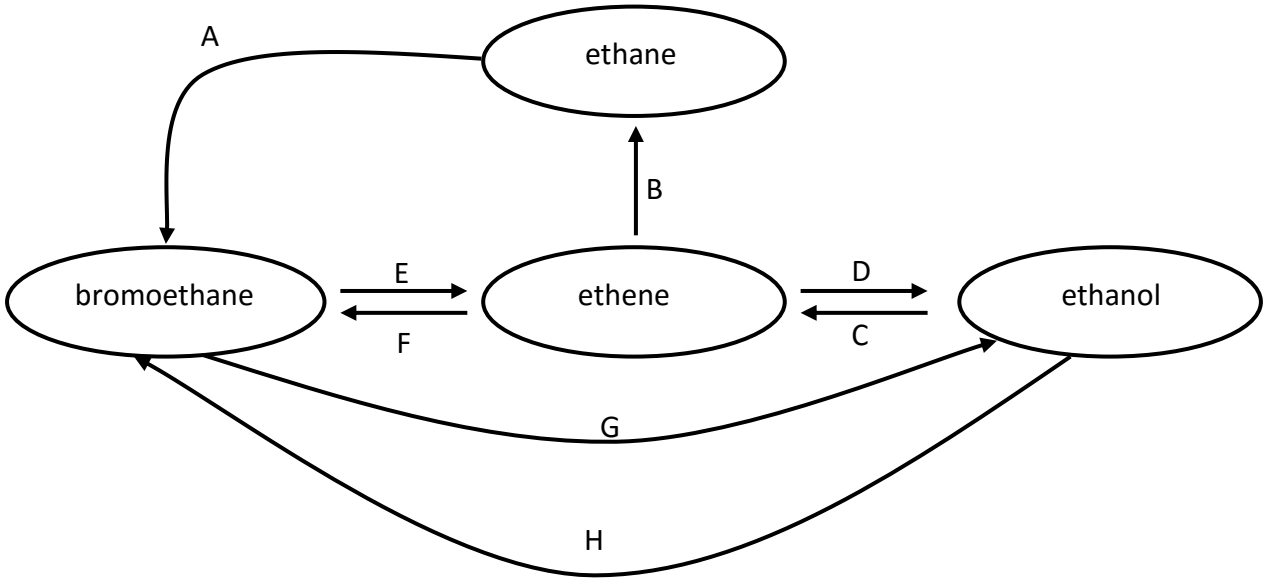
1.3 Consider reaction **C**.

1.3.1	Ethene is a monomer of compound **Q.** Explain clearly what this statement means.	(2)
1.3.2	Reaction **C** is an example of polymerisation reactions. Name the type of polymerisation of which reaction **C** is an example.	(1) (2)
1.3.3	Write down the STRUCTURAL FORMULA of polymer **Q** indicating ONLY two repeating units.	

[15]

QUESTION 2

The flow diagram below illustrates some of the many reactions ethene undergoes.



2.1 Write down the structural formula of ethane (2)

2.2 Why is it not advisable to place a banana that has been artificially ripened alongside a cabbage and lettuce? (2)

2.3 Write down the general formula for the homologous series to which ethene belongs. (1)

2.4 Name the type of reaction represented by each of the letters A, B, D and H. Write down the letters A, B, D and H and next to each the type of reaction. (4)

2.5 Use structural formulae to write down a balanced equation for reaction B. (3)

2.6 Apart from ethene, which other reactant is needed for reaction F? Write down the FORMULA only. (2)

2.7 Both reactions E and G occur in the presence of a base. Reaction E is an elimination reaction and reaction G is a substitution reaction.

2.7.1 How is the base in reaction E different from the base in reaction G? (2)

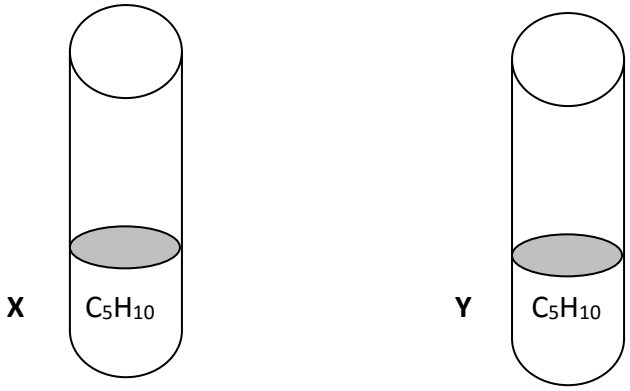
2.7.2 Name the type of elimination reaction represented by E. (1)

[17]

QUESTION 3

You have two test tubes containing equal amounts of compounds X and Y respectively. Both have the same molecular formula C_5H_{10}. You have to distinguish which compound, X or Y, is saturated.

You hypothesise that compound X is saturated.



3.1 Design an investigation to show that your hypothesis is true. Use the following to write down your design (write only the question number and next to it your answer):

3.1.1 Write down your investigative question. (2)

3.1.2 Write down a list of apparatus and chemicals you will use. (2)

3.1.3 State the safety precautions that you will take. (2)

3.1.4 Write down the procedure you will follow. (4)

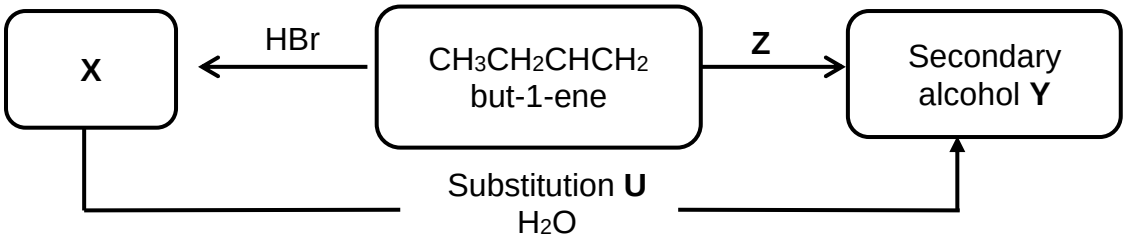
3.2 Describe how you will use your observations to verify your hypothesis. (2)

3.3 Write down the IUPAC name of compound Y. (2)

[14]

QUESTION 4 : (Start on a new page)

In industry alkenes are used in the synthesis of a variety of organic compounds. The flow diagram below illustrates some of the many possible reactions.



4.1 Use structural formulae to write a balanced equation for the formation of COMPOUND **X.** (4)

4.2 Name the type of reaction that takes place when but-1-ene is converted to COMPOUND **X.** (1)

4.3 Write down the structural formula and IUPAC name of the SECONDARY ALCOHOL **Y,** that is formed. (3)

4.4 Name the type of substitution reaction **U** that takes place when COMPOUND **X** is converted to the SECONDARY ALCOHOL **Y.** (1)

4.5 With the aid of a catalyst, but-1-ene can be converted directly to the secondary alcohol, without the formation of the intermediate compound **X.**

4.5.1 Besides but-1-ene, write down the NAME of the other reactant needed for this reaction **Z**. (1)

4.5.2 Write down the FORMULA of the catalyst that can be used. (1)

4.5.3 Name the type of REACTION **Z** that will take place during this direct conversion. (1)

4.6 Instead of adding water to compound X, concentrated sodium hydroxide is added and the mixture is heated.

4.6.1 Write down the IUPAC name of the organic product that is formed. (1)

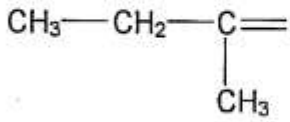
4.6.2 Name the TYPE of reaction that takes place. (1)

[14]

QUESTION 5

5.1 Write down the structural formulae and IUPAC names for the product(s) formed when the following compounds react with each other:

5.1.1 cyclohexene and HCℓ (3)

5.1.2  and HBr (3)

5.2 The following equations represent chemical reactions:

Reaction 1: $A + HBr \rightarrow CH_3\text{-}CH_2\text{-}CH_2Br + H_2O$

Reaction 2: $CH_3\text{-}CH_2\text{-}CH_2Br \xrightarrow{NaOH} A + NaBr$

5.2.1 Name the type of reaction in reaction 2. (1)

5.2.2 Write down the structural formula for the organic compound A. (2)

5.3 Cracking is a process that is generally used in the oil industry.

5.3.1 What is meant by *cracking*? (2)

5.3.2 Why is cracking used in the fuel industry? (2)

5.3.3 Give a reason for the difference in the melting and boiling points of the following two compounds, produced from a specific cracking process:

COMPOUND	MELTING POINT (°C)	BOILING POINT (°C)
Butane	-138	-1
Heptane	-91	89

(2)

5.3.4 In which phase (gas, liquid or solid) is each of the following when used as a fuel:

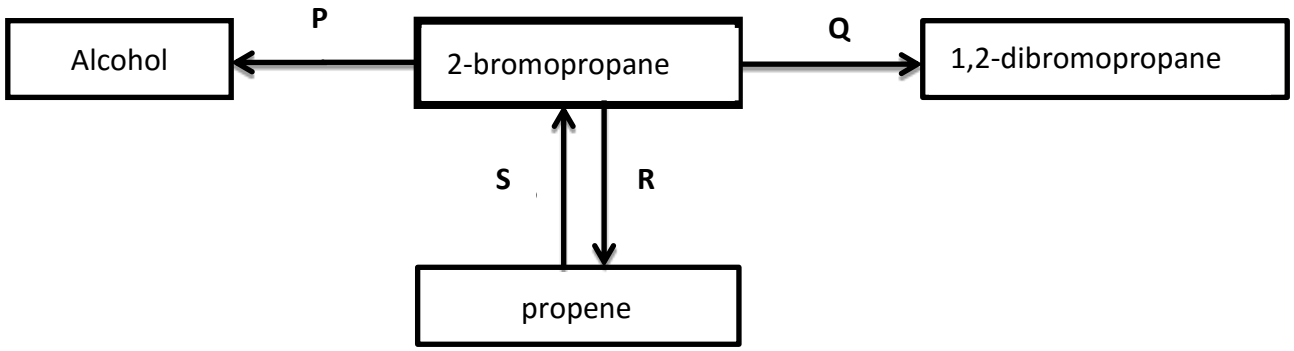
(a) Butane

(b) Heptane (2)

[17]

QUESTION 6 (Start on a new page.)

The flow diagram below shows various chemical reactions of haloalkanes. P, Q and R represent reaction types.



6.1 Write down the type of reaction represented by:

6.1.1 **Q** (1)

6.1.2 **R** (1)

6.2 For reaction **P**, write down the following:

6.2.1 The structural formula of the alcohol formed (2)

62.2 The IUPAC name of the alcohol formed (1)

6.3 In reaction **S**, propene reacts with compound X to form 2-bromopropane.

Write down the:

4.3.1 **NAME** of compound X (1)

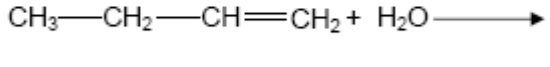
4.3.2 Balanced equation using structural formulae (4)

[10]

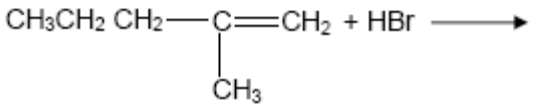
QUESTION 7

Most organic compounds can undergo substitution or addition or elimination reactions to produce a variety of organic compounds. Some incomplete organic reactions are represented below.

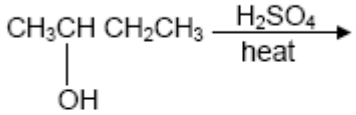
Reaction I



Reaction II



Reaction III



7.1 Name the type of reaction represented by reaction III. (1)

7.2 Both reactions I and II are examples of addition reactions. Name the type of addition that is represented by each reaction. (2)

7.3 Write down the structural formula and IUPAC name of the major product formed in reaction I. (3)

7.4 Reaction I only takes place in the presence of a catalyst. Write down the formula of the catalyst used in reaction I. (1)

7.5 Write down the structural formula and IUPAC name of the major product formed in reaction II. (3)

7.6 To which homologous series does the organic product formed in reaction III belong? (2)
[12]

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

SUBJECT: PHYSICAL SCIENCE

MOMENTUM

2019

SESSION 3

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

Session 2

Momentum and Impulse

Momentum

- Define *momentum* as the product of an object's mass and its velocity.
- Describe the *linear momentum* of an object as a vector quantity with the same direction as the velocity of the object.
- Calculate the momentum of a moving object using p = mv.
- Describe the *vector nature of momentum* and illustrate it with some simple examples.
- Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the above examples.

Newton's second law of motion in terms of momentum

- State Newton's second law of motion in terms of momentum: The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force.
- Express Newton's second law of motion in symbols: $F_{net} = \frac{\Delta p}{\Delta t}$

- Calculate the change in momentum when a resultant/net force acts on an object and its velocity:

  - Increases in the direction of motion, e.g. 2nd stage rocket engine fires
  - Decreases, e.g. brakes are applied
  - Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from

Impulse

- Define *impulse* as the product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.
- Deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$.
- Use the impulse-momentum theorem to calculate the force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.
- Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.

Conservation of momentum and elastic and inelastic collisions

- Explain what is meant by *a closed/an isolated system* (in Physics), i.e. a system on which the resultant/net external force is zero.

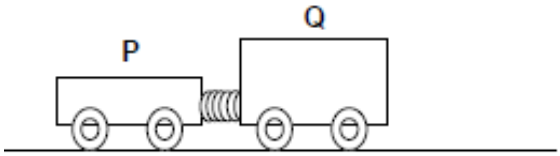
- A closed/an isolated system exclude external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.

- State the principle of conservation of linear momentum: The total linear momentum of a closed system remains constant (is conserved).
- Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.
- Distinguish between *elastic collisions* and *inelastic collisions* by calculation.

Question 1
Multiple choice questions

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

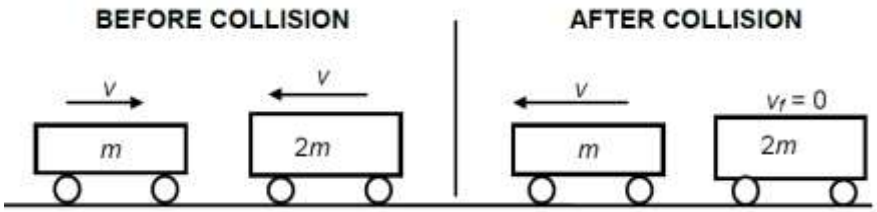
1.1. Two trolleys, P and Q, of mass *m* and *2m* respectively are at rest on a frictionless horizontal surface. The trolleys have a compressed spring between them.



The spring is released and the trolleys move apart. Which ONE of the following statements is TRUE?

A **P** and **Q** have equal kinetic energies.
B The speed of **P** is less than the speed of **Q**.
C The sum of the kinetic energies of **P** and **Q** is zero.
D The sum of the final momentum of **P** and **Q** ia zero.

1.2. An object of mass *m* moving at constant velocity *v* collides head-on with an object of mass *2m* moving in the opposite direction at velocity *v* in the opposite direction and the larger mass is brought to rest. Refer to the diagram below.



Ignore the effects of friction.

Which ONE of the following is CORRECT?

	MOMENTUM	MECHANICAL ENERGY
A	Conserved	Conserved
B	Not Conserved	Conserved
C	Conserved	Not Conserved
D	Not Conserved	Not Conserved

1.3. Two bodies undergo an INELASTIC collision in the absence of friction. Which ONE of the following combinations of momentum and kinetic energy of the system is CORRECT?

	MOMENTUM	KINETIC ENERGY
A	Not Conserved	Conserved
B	Conserved	Not Conserved
C	Not Conserved	Not Conserved
D	Conserved	Conserved

1.4. Airbags in modern cars provide more safety during an accident.
The statements below are made by a learner to explain how airbags can ensure better safety in a collision.

(i) The time of impact increases.
(ii) The impact force decreases.
(iii) The Impulse increases.

A (i) only

B (ii) only
C (ii) and (iii) only
D (i) and (ii) only

[4 × 2 = 8]

Questions 2-6 is possible examples of question 4 from final exam papers on Momentum and Impulse

Question 2

Two boys, each of mass *m*, are standing at the back of a flatbed trolley of mass *4m*. The trolley is as at rest on a frictionless horizontal surface.

The boys jump of simultaneously at one end of the trolley with a horizontal velocity of $2 m \cdot s^{-1}$. The trolley moves in the opposite direction.

2.1. Write down the *principle of conservation of linear momentum* in words. (2)

2.2. Calculate the final velocity of the trolley. (5)

2.3. The two boys jump of the trolley one at a time. How will the velocity of the trolley compare to that calculated in QUESTION 2.2? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

[8]

Question 3

Dancers have to learn many skills, including how to land correctly. A dancer of mass 50 kg leaps into the air and lands feet first on the ground. She lands on the ground with a velocity of $5 m \cdot s^{-1}$. As she lands, she bends her knees and comes to a complete stop in 0,2 seconds.

3.1. Calculate the momentum with which the dancer reaches the ground. (3)

3.2. Define the term *Impulse* of a force. (2)

3.3. Calculate the magnitude of the net force acting on the dancer as she lands. (3)

Assume that the dancer performs the same jump as before but lands without bending her knees.

3.4. Will the force now be GREATER THAN, SMALLER THAN or EQUAL TO the force calculated in QUESTION 3.3? (1)

3.5. Give a reason for the answer to QUESTION 3.4. (3)

[12]

Question 4

A bullet of mass 20 g is fired from a stationary rifle of mass 3 kg. Assume that the bullet moves horizontally. Immediately after firing, the rifle recoils (moves back) with a velocity of 1,4 $m \cdot s^{-1}$.

4.1. Calculate the speed at which the bullet leaves the rifle. (4)

The bullet strikes a stationary 5 kg wooden block **fixed** to a flat, horizontal table. The bullet is brought to rest after travelling a distance of 0,4 m **into the block**. Refer to the diagram below.

4.2. Calculate the magnitude of the average force exerted by the block on the bullet. (5)

4.3. How does the magnitude of the force calculated in QUESTION 4.2 compare to the magnitude of the force exerted by the bullet on the block? Write down only LARGER

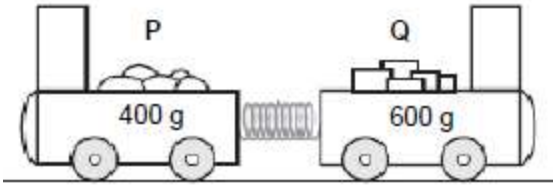
THAN, SMALLER THAN or THE SAME.

(1)

[10]

Question 5

The diagram below shows two trolleys, P and Q, held together by means of a compressed spring on a flat, frictionless horizontal track. The masses of P and Q are $400\ g$ and $600\ g$ respectively.



When the trolleys are released, it takes $0{,}3\ s$ for for the spring to unwind to its natural length. Trolley Q then moves to the right at $4\ m \cdot s^{-1}$.

5.1. State the *principle of conservation of linear momentum* in words. (2)

5.2. Calculate the:

5.2.1. Velocity of trolley P after the trolleys is released. (4)

5.2.2. Magnitude of average force exerted by the spring on trolley Q. (4)

5.3. Is this an elastic collision? Only answer YES or NO. (1)

[11]

EXTRA MOMENTUM QUESTIONS

1. DEFINITIONS IN THIS TOPIC MUST BE GIVEN TO LEARNERS AT THE BEGINNNG OF THE TOPIC AND SHOULD BE LEARNED :
   - MOMENTUM
   - IMPULSE
   - NEWTONS SECOND LAW IN TERMS OF MOMENTUM
   - STATE CONSERVATION OF PRINCIPLE OF LINEAR MOMENTUM
2. CONVERSIONS SHOULD BE EMPHASISED BEFORE CALCULATIONS i.e. **MASS IN (kg),VELOCITY IN $m.s^{-1}$, FORCE IN NEWTON (N)**
3. LEARNERS MUST BE EXPOSED TO THE FOLLOWING CALCULATIONS

- CALCULATION OF BOTH INITIAL AND FINAL MOMENTUM SEPARATELY
- CALCULATION OF CHANGE IN MOMENTUM-EMPHASIZE THE CHOICE OF DIRECTIONS AT ALL TIMES EVEN IF THE CHANGE WILL BE IN THE SAME DIRECTION.
- CONSERVATION OF LINEAR MOMENTUM-LEARNERS NEED TO KNOW THAT NO EQUATION WILL BE GIVEN IN THE FORMULAR SHEET.

  $\sum p$ (before collision) = $\sum p$ (after collision) **[$\sum$ MEANS THE SUM/TOTAL/NET]**

  $m_1vi_1+m_2vi_2 = m_1vf_1+m_2vf_2$

  $(m_1+m_2)vi = m_1vf_1+m_2vf_2$

  $m_1vi_1+m_2vi_2 = (m_1+m_2)vf$

- CALCULATIONS TO PROOF THAT COLLISSIONS ARE ELASTIC OR INELASTIC **[CALCULATE TOTAL KINETIC ENERGY BEFORE COLLISION THEN TOTAL KINETIC ENERGY AFTER COLLISION, AND COMPARE THE ANSWERS]**

  ****NB FOR ELASTIC COLLISION THE TOTAL KINETIC ENERGY BEFORE = TOTAL KINETIC ENERGY AFTER COLLISION,AND FOR INELASTIC COLLISION,THE ANSWERS ARE NOT THE SAME]**
- CALCULATIONS OF IMPULSE **[$F_{NET}\Delta t=\Delta P$]**

  ***NB: **LEARNERS SHOULD ALSO BE ABLE TO CALCULATE F_{NET} FROM THIS EQUATION AND ALSO TO EXPLAIN THE RELATIONSHIP BETWEEN F_{NET} AND Δt**

  LEARNERS SHOULD BE ABLE TO DRAW GRAPHS REPRESENTING THE RELATIONSHIP BETWEEN F_{NET} AND Δt

MOMENTUM QUESTIONS MAY INCLUDE SCENARIOS LIKE : COLLIDING BALLS , CARS COLLIDING WITH EACH OTHER, A PENDULUM, SKATEBOARDS WITH A PERSON ON, A GUN RECOILING OR A BOAT ETC.

MULTIPLE CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (1.1–1.5)

1.1 Net force is the measure of the...

A. change in energy
B. rate of change in energy
C. change in momentum
D. rate of change in momentum

1.2 During a collision an inflated air bag in a car decreases the net force that would have acted on the driver of the car. This is because the time interval over which the net force acts on the driver … for the same momentum change.

A. is zero
B. decreases
C. increases
D. remains constant

1.3 An object of mass m moving at velocity v collides head-on with an object of mass 2m moving in the opposite direction at velocity v. Immediately after the collision the smaller mass moves at velocity v in the opposite direction and the larger mass is brought to rest. Refer to the diagram below

BEFORE COLLISSION **AFTER COLLISSION**

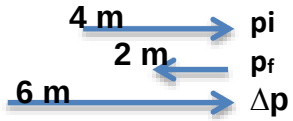
Ignore the effect of friction.Which of the following is correct:

	MOMENTUM	**MECHANICAL ENERGY**
A	Conserved	conserved
B	Not conserved	conserved
C	Conserved	Not conserved
D	Not conserved	Not conserved

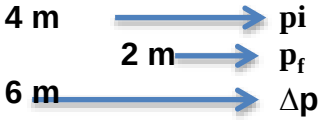
1.4 If the momentum of an object is doubled, then its kinetic energy is...
A. halved.
B. doubled.
C. three times greater.
D. four times greater.

1.5 A ball of mass m, moving horizontally to the right, strikes the wall with a velocity of 4 m•s^{-1}. The ball rebounds in the opposite direction with the velocity of 2 m•s^{-1}.
Which one of the following correctly represents the momentum vectors of the initial momentum (pi), the final momentum (pf) and the change in momentum (Δp) of the ball in kg•m•s^{-1}

A



B



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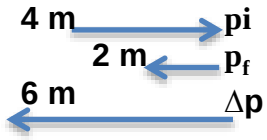
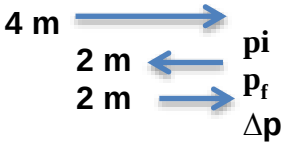


D

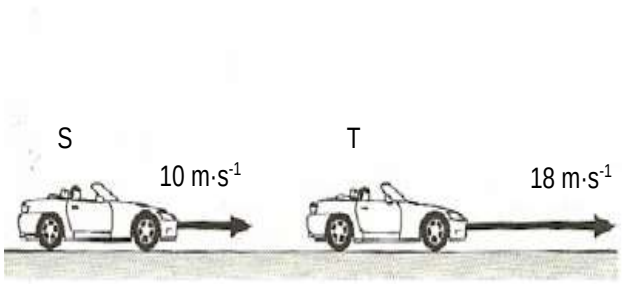


[10]

STRUCTURED QUESTIONS

QUESTION 1

Two cars S and T travelling on a straight road approach a robot at velocities of 10m.s^{-1} East and 18 m·s^{-1} East respectively as shown in the sketch. Ignore the effect of friction. Car T suddenly stops and car S collides with car T. After the collision the two cars move off together as a unit. The combined mass of each car with the driver is 1500 kg



1.1.1 Calculate the speed of the two cars immediately after the collision. **[5 m•s^{-1}]** (4)

Research has shown that forces greater than 85 000 N during collisions may cause fatal injuries. The collision described above lasts for 0, 08 s.

1.1.2 Determine, by means of calculations, whether the collision above could result in a fatal injury. **[93 750 N]** (4)

The cars have crumple zones, seat belts, air bags and padded interiors that can reduce the chance of death or serious injury during accidents.

1.1.3 Use principles of Physics to explain how air bags can reduce the risk of injury or death. (3)

[11]

QUESTION 2

2.1 Two boys, each of mass m, are standing at the back of a flatbed trolley of mass 4 m. The trolley is at rest on a frictionless horizontal surface.
The boys jump off simultaneously at one end of the trolley with a horizontal velocity of 2 m·s^{-1}. The trolley moves in the opposite direction.

2.1.1 Write down the *principle of conservation of linear momentum* in words. (2)

2.1.2 Calculate the final velocity of the trolley**. [1m•s^{-1}]** (5)

2.1.3 The two boys jump off the trolley one at a time. How will the velocity of the trolley compare to that calculated in QUESTION 2.2?
Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

[8]

QUESTION 3

3.1 A girl of mass 40 kg is given a lift on the back of a 10 kg bicycle by a boy of mass 30 kg. They travel at a constant speed of 2,5 m•s^{-1}.
The girl wishes to get off the back of the bicycle while it is still moving.

3.1.1 She knows that if she just puts her feet on the ground and stands up, she is likely to fall over. Use the law in physics to explain why she falls over. (2)

So instead, she pushes herself off the back of the bicycle by pushing in the direction of the movement on the bicycle frame with her hands, so that she lands on the ground with zero horizontal velocity.

3.1.2 State the law of conservation of momentum in words. (2)

3.1.3 Calculate the magnitude of the velocity of the bicycle and the boy immediately after the girl has left the bicycle. **[5 m.s^{-1}]** (4)

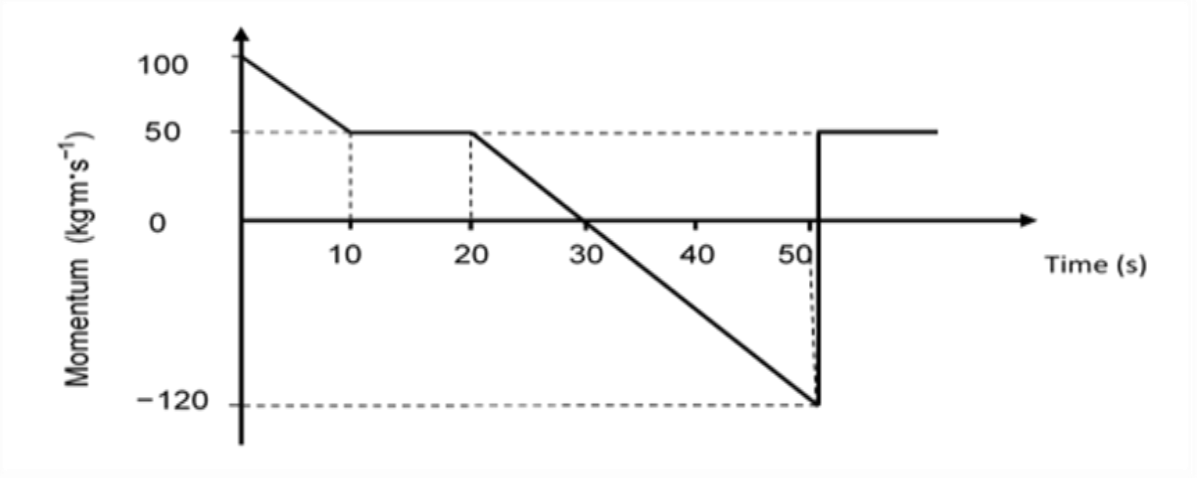
3.1.4 Calculate the total kinetic energy of the system (bicycle and both children) before and after the girl gets off**. [250J, 500J]** (4)

Explain the reason for any difference. (1)

[13]

QUESTION 4

4.1 The momentum versus time graph of object **A**, originally moving horizontally EAST, is shown



4.1.1 Write down the definition of *momentum* in words. (2)

4.1.2 The net force acting on object **A** is ***zero*** between t = 10 s and t = 20 s. Use the graph and a relevant equation to explain why this statement is

TRUE.
(2)

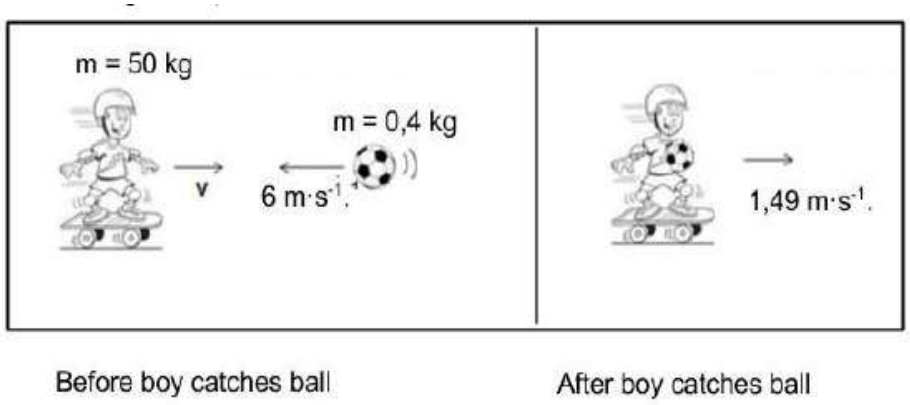
4.1.3 Calculate the magnitude of the impulse that object **A** experiences between t = 20 s and t = 50 s. **[170N.s]** (3)

4.1.4 At t = 50 s, object **A** collides with another object, **B**, which has a momentum of 70 kg·m·s^{-1} EAST. Use the information from the graph and the relevant principle to calculate the momentum of object **B** after the collision. **[100 kg.m•s^{-1}]**
(5)

[12]

QUESTION 5

A boy on a skateboard moves to the right at constant velocity. The joint mass of the boy and skateboard is 50 kg. He catches a ball with of mass 0, 4 kg that is travelling horizontally to the left at a velocity of 6 m·s^{-1}. After the boy catches the ball, they both move to the right at 1,49 m·s^{-1}.



5.1 Define the term impulse. (2)

5.2 Calculate the magnitude of the average force that the boy exerts on the ball when he catches it, if he and the ball exert a force for a period of 0,1 s on each other.**[29,96N]** (3)

5.3 Write down the Principle of Conservation of Momentum. (2)

5.4 Calculate the magnitude of the velocity v of the boy before he catches the ball.**[1,55m·s^{-1}]** (3)

5.5 Prove with the necessary calculation that this is an inelastic collision. **[$\sum Ek_b$ = 67,26J; $\sum Ek_a$ = 55,95J] Inelastic collision** (5)

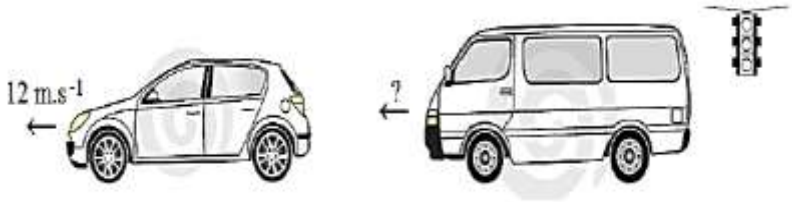
[15]

QUESTION 6

A car of mass 1 500 kg is stationary at a traffic light. It is hit from behind by a minibus of mass 2 000 kg travelling at a speed of 20 m•s^{-1}. Immediately after the collision the car moves forward at 12 m•s^{-1}.

BEFORE

AFTER



6.1 State the LAW OF CONSERVATION OF LINEAR MOMENTUM in words. (2)

6.2 Calculate the speed of the minibus immediately after the collision. **[11m·s^{-1}]** (4)

6.3 The driver of the minibus is NOT wearing a seatbelt.
Describe the motion that the driver undergoes immediately after the collision. (1)

6.4 State the law of physics which can be used to explain your answer about the motion of the driver in QUESTION 6.3. (2)
[9]

QUESTION 7

A 0,5 kg soccer ball, moving horizontally at 6 m.s^{-1}, collides with a soccer player's head and is headed directly back at 9 m.s^{-1}. The ball is in contact with the player's head for 0,02 s. Ignore the effects of friction.

7.1 What is the relationship between impulse and change in momentum? (1)

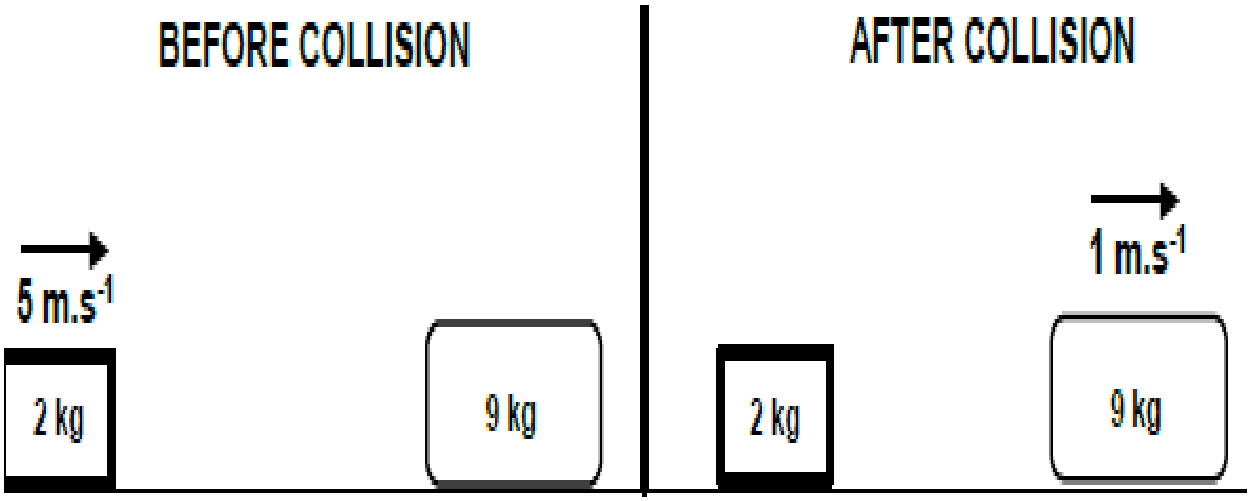
7.2 Is the total momentum conserved during this collision?
Provide a reason for your answer. (2)

7.3 Calculate the magnitude of the average force exerted by the soccer player's head on the ball.**[375N]** (4)

7.4 A second ball is pumped to its maximum volume so that it cannot be compressed. Assume that the two balls have the same mass. If the second ball strikes the soccer player's head with a velocity of 6 m.s^{-1}, will the force exerted by the soccer player's head on the ball be greater than, less than or equal to the force calculated in question 7.3. Give a reason for your answer. (3)
[10]

QUESTION 8

A wooden block of mass 2 kg, moving at a velocity of 5 m·s^{-1}, collides with a crate of mass 9 kg resting on a flat horizontal surface as shown in the diagram below. After the collision, the crate moves to the right at 1 m·s^{-1}. Ignore the effects of friction.



8.1 Write down the principle of conservation of linear momentum in words. (2)

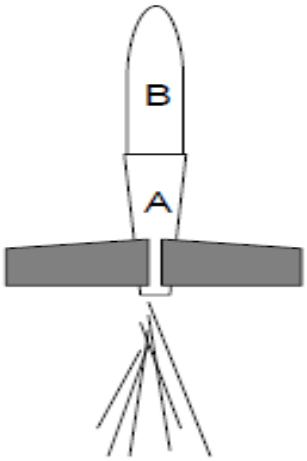
8.2 Calculate the magnitude of the velocity of the wooden block immediately after the collision.**[0,5m·s^{-1}]** (4)

8.3 If the collision lasts 0,6 seconds, calculate the force the wooden block exerts on the crate during the collision.**[15N]** (4)

[10]

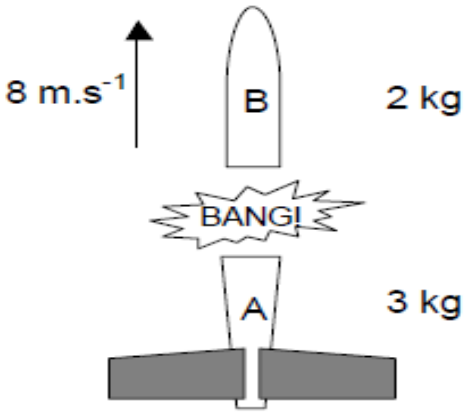
QUESTION 9

Hendrik is an amateur rocket builder. He launches a two-stage rocket as shown below. Section A (stage 1) contains the rocket engine and fuel. Section B (stage 2) has a mass of 2 kg.



9.1 Hendrik says that Newton's Third Law of Motion is used to explain why the rocket moves upwards. Identify one action-reaction pair of forces involved with the launching. (2)

At a certain height, when the rocket has a velocity of 5 $m.s^{-1}$, the last fuel is used up and section A then has a mass of 3 kg. To get section B even higher, a small explosion separates section B from section A at this point and increases the upward velocity of section B to 8 $m.s^{-1}$.



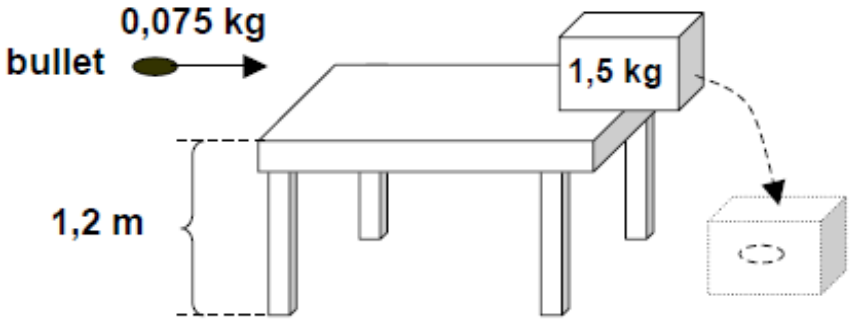
9.2 State, in words, the principle of conservation of momentum. (3)

9.3 Calculate the velocity of section A after the explosion. **[3 m·s^{-1}]** (6)

[11]

QUESTION 10

A 1,5 kg block of wood is placed on the edge of a table 1,2 m above the floor. The block is struck by a bullet, mass 0,075 kg, moving at an unknown, horizontal velocity. After the impact, the bullet is embedded in the block, which falls to the floor. The block strikes the floor with a speed of 8 m.s^{-1}. Ignore all types of friction.



Calculate:

10.1 Write down the principle of conservation of linear momentum words. **(**2)

10.2 The magnitude of the velocity with which the bullet strikes the block. **[132,72 m·s^{-1}]** (7)

10.3 The magnitude of the impulse of the bullet during the impact. [**9,48N·s]** (5)

[14]