NORTHERN CAPE
DEPARTMENT OF EDUCATION

NOORD KAAP

DEPARTEMENT VAN ONDERWYS

LEFAPHA LA THUTO

GRADE 12
SUBJECT SUPPORT PACKAGE
2024

PHYSICAL SCIENCES

#EASY PASS

CONTENTS

P1 PHYSICS

NEWTON'S LAWS

For NSC there will be ±20 marks from this topic. Our target is at least 10 marks.

Newton's first law of motion - A body will remain in its state of rest or uniform motion unless a non-zero net force acts on it.

From the data sheet we have Newton's second law as $F_{net} = ma$

$$a = \frac{F_{net}}{m}$$

Acceleration is directly proportional to net force.

Acceleration is inversely proportional to mass.

Newton's Second law of motion - Acceleration of an object is directly proportional to the net force and inversely proportional to the mass.

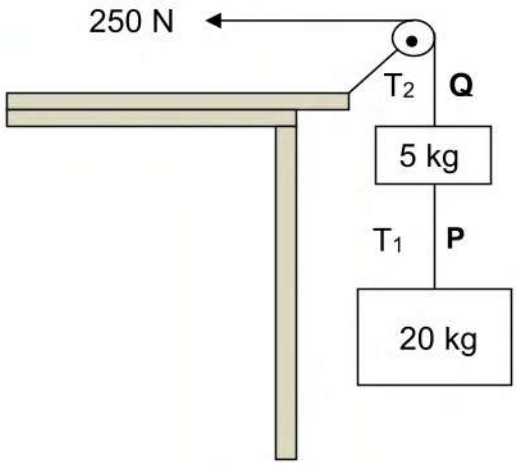
Newton's third law of motion - When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.

Normal force - The force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.

WORKED EXAMPLES

QUESTION 1

Two blocks of masses 20 kg and 5 kg respectively are connected by a light inextensible string, **P**. A second light inextensible string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley. A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T_1 and T_2 respectively. Ignore the effects of air friction.



1.1 State Newton's Second Law of Motion in words. (2)

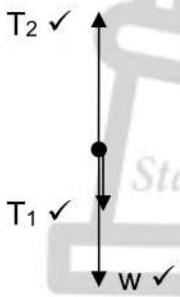
1.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**. (3)

1.3 Calculate the magnitude of the tension T_1 in string **P**. (5)
[10]

Solution

1.1 Acceleration of an object is directly proportional to the net force and inversely proportional to the mass.✓✓ (2)

1.2 Drawing free body diagram is very important to solve problems. The marks is a good indication about the number of forces acting on the body. Here it is a 3 mark question. So there are 3 forces.
5 kg block is tied by 2 strings. So there will be 2 tensions.
Tension, T_1- acting downward due to the weight of 20 kg
Tension T_2- Acting upward which is equal to the applied force of 250 N.
Gravitational force (F_G)- Acting vertically down.



(3)

1.3 For this type of problems to find acceleration or Tension you need to apply $\mathbf{F_{net} = ma}$ to each bodies (Here 5 kg and 20 kg). Then you will get 2 equations that need to solve simultaneously.

Consider 5 kg block	Consider 20 kg block
3 forces are acting on 5 kg block. T_2 upwards which is equal to 250 N. T_1 and F_g down ward. Net downward force is $(T_1 + F_g)$ If upward is + ve then downward is -ve So net force on 5 kg is $T_2 + -(T_1 + F_g)$ $F_{net} = ma$✓ $T_2 + -(T_1 + F_g) = ma$ $250 - (5)(9,8) - T_1$✓$= 5\ a$✓ $201 - T_1 = 5\ a$ $T_1 = 201 - 5a$.....(1)	2 forces are acting on 20 kg block. T_1 upwards F_g down ward If upward is + ve then downward is -ve So net force on 20 kg is $T_1 + (-F_g)$ $F_{net} = ma$ $T_1 + (-mg) = ma$ $T_1 + [-20(9,8)]$ ✓ $= 20a$ $T_1 - 196 = 20a$.....(2)

Substitute the value of T_1 from equation(1) in equation (2)

$(201-5a) - 196 = 20a$
$201-196 = 20a+5a$
$5 = 25a$
$a = m{\cdot}s^{-2}$

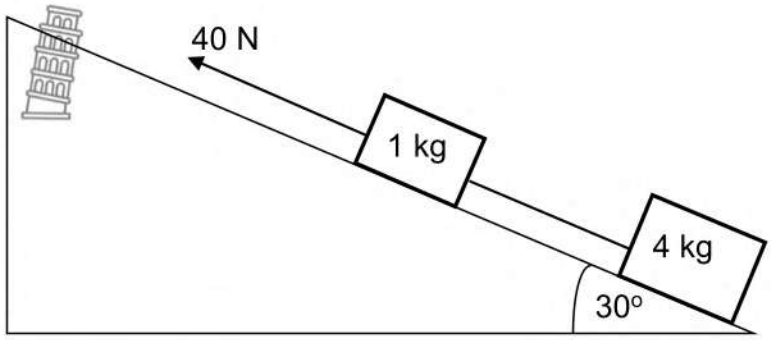
We need to find T_1. So substitute the value of a in equation (1)

$T_1 = 201 - 5a$
$= 201 - 5(0,2)$
$= 200$ N ✓

(5)
[10]

QUESTION 2

A block of mass 1 kg is connected to another block of mass 4 kg by a light inextensible string. The system is pulled up a rough plane inclined at 30° to the horizontal, by means of a constant 40 N force parallel to the plane as shown in the diagram below.



The magnitude of the kinetic frictional force between the surface and the 4 kg block is 10 N. The coefficient of kinetic friction between the 1 kg block and the surface is 0,29.

2.1 State Newton's third law in words. (2)

2.2 Draw a labelled free-body diagram showing ALL the forces acting on the **1 kg block** as it moves up the incline. (5)

2.3 Calculate the magnitude of the:

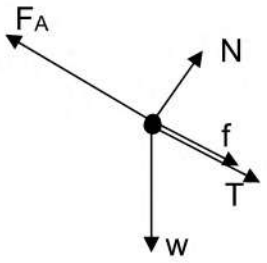
2.3.1 Kinetic frictional force between the 1 kg block and the surface (3)

2.3.2 Tension in the string connecting the two blocks (6)
[16]

Solution

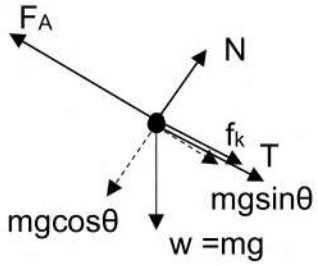
2.1 When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body. (2)

2.2 This is a 5 mark question, which means that there are 5 forces acting on 1 kg.
Applied force (F_A = 40 N)
Normal force which is perpendicular to the surface
Force friction downwards which is opposite to the direction of motion
Gravitational force which is vertically downwards
1 kg is connected to 4 kg by a string. So there is a Tension downwards.



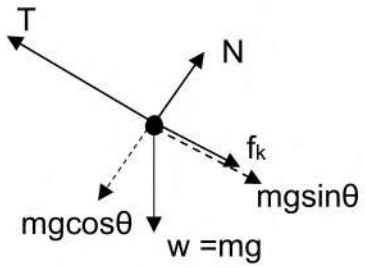
(5)

2.3.1

To solve this question and the next question we need to split the weight, mg of the objects into the corresponding perpendicular components mgcosθ and mgsinθ. See the splitting for 1 kg object. You can see that normal force N is equal and opposite of mgcosθ  	$f_k = \mu_k N$ (substitute N = mgcosθ) $= \mu_k$ mgcosθ✓ = 0,29 (1 x 9,8 cos 30°) ✓ = 2,46 N✓

(3)

2.3.2

For 1 kg block/*Vir 1 kg blok*	For 4 kg block/*Vir 4 kg blok*
Refer the free body diagram above. There are 3 forces acting downwards. Mg sinθ, Tension and friction. So net downward force is mg sinθ + T + f_k But applied firce F_A= 40 N is acting upwards. We take the upward as +ve and downward as -ve. Therefore the net force is **F_A + -(mg sinθ + T + f_k)** We got already that f_k = 2,46 N in 2.3.1 F_{net} = ma✓ $F_A - \{(T+f_k) + mg\sin\theta\} = ma$ $40 - \{T + 2,46 + 1(9,8)(\sin 30°)\}$✓= (1)a ✓ 40 – T – 7,36 = a 32,64 – T = a T = 32,64 – a .....(1)	Freebody diagram for 4 kg is shown below.  There are 2 forces acting downward. fk and mgsinθ So net downward force is mg sinθ + f_k For 4 kg T is upward. Take the upward as +ve and downward as -ve. Therefore the net force is **T + -(mg sinθ + f_k)** F_{net} = ma $T + - (mg\sin\theta + f_k) = 4a$ $T - (4 \times 9,8 \sin 30° + 10) = 4a$✓ T- 29,6 = 4a.....(2)

Equation (2) is T- 29,6 = 4a
Substitute the value of T = 32,64 – a in equation (2):
(32,64 – a) - 29,6 = 4a
32,64 – 29,6 = 5a
3,04 = 5a
a = 0,61 $m \cdot s^{-2}$
Substitute the value of a in equation (1):
T = 32,64 – a .....(1)
= 32,64 – 0,61✓
T = 32,03 N✓

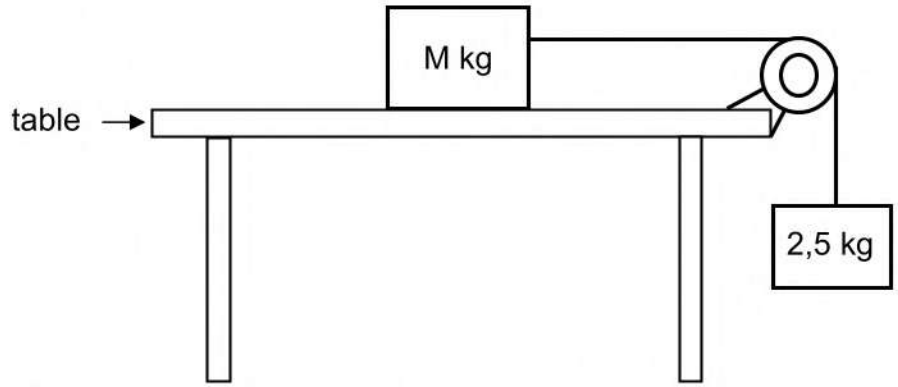
(6)
[16]

EXERCISES

QUESTION 1

1.1 Two blocks of mass M kg and 2,5 kg respectively are connected by a light, inextensible string. The string runs over a light, frictionless pulley, as shown in the diagram below.

The blocks are **stationary**.



1.1.1 State Newton's THIRD law in words. (2)

1.1.2 Calculate the tension in the string. (3)

The coefficient of static friction (μ_s) between the unknown mass M and the surface of the table is 0,2.

1.1.3 Calculate the minimum value of M that will prevent the blocks from moving. (5)

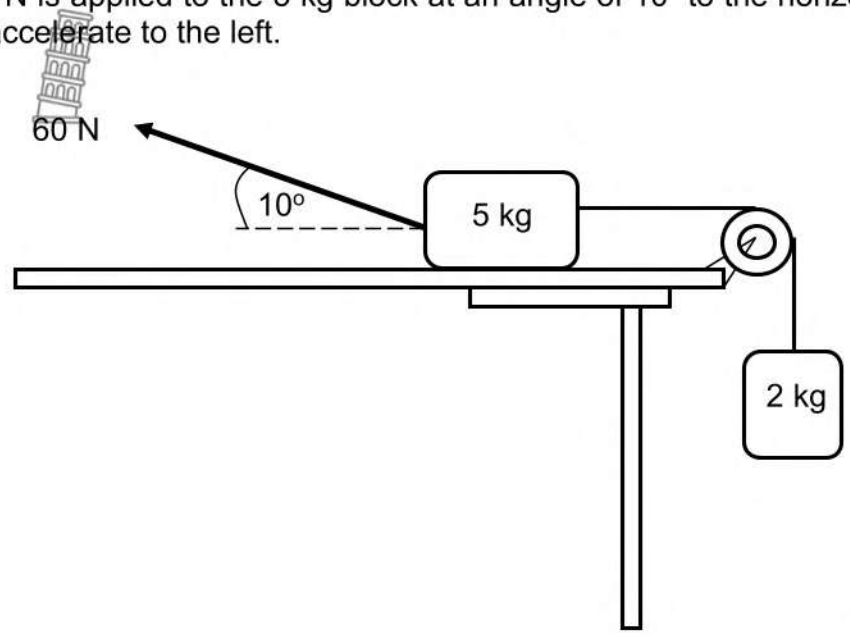
The block of unknown mass M is now replaced with a block of mass 5 kg. The 2,5 kg block now accelerates downwards. The coefficient of kinetic friction (μ_k) between the 5 kg block and the surface of the table is 0,15.

1.1.4 Calculate the magnitude of the acceleration of the 5 kg block. (5)
[15]

QUESTION 2

A 5 kg block, resting on a rough horizontal table, is connected by a light inextensible string passing over a light frictionless pulley to another block of mass 2 kg. The 2 kg block hangs vertically as shown in the diagram below.

A force of 60 N is applied to the 5 kg block at an angle of 10° to the horizontal, causing the block to accelerate to the left.



The coefficient of kinetic friction between the 5 kg block and the surface of the table is 0,5. Ignore the effects of air friction.

2.1 Draw a labelled free-body diagram showing ALL the forces acting on the 5 kg block. (5)

2.2 Calculate the magnitude of the:

2.2.1 Vertical component of the 60 N force (2)

2.2.2 Horizontal component of the 60 N force (2)

2.3 State Newton's Second Law of Motion in words. (2)

Calculate the magnitude of the:

2.4 Normal force acting on the 5 kg block (2)

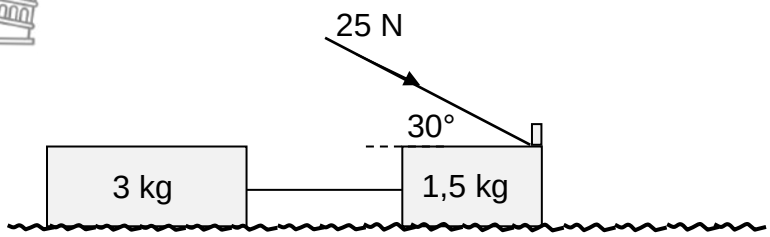
2.5 Tension in the string connecting the two blocks (7)

[20]

QUESTION 3

A learner constructs a push toy using two blocks with masses 1,5 kg and 3 kg respectively. The blocks are connected by a massless, inextensible cord.

The learner then applies a force of 25 N at an angle of 30° to the 1,5 kg block by means of a light rigid rod, causing the toy to move across a flat, rough, horizontal surface, as shown in the diagram below.



The coefficient of kinetic friction (μ_k) between the surface and each block is 0,15.

3.1 State Newton's Second Law of Motion in words. (2)

3.2 Calculate the magnitude of the kinetic frictional force acting on the 3 kg block. (3)

3.3 Draw a labelled free-body diagram showing ALL the forces acting on the 1,5 kg block. (5)

3.4 Calculate the magnitude of the:

3.4.1 Kinetic frictional force acting on the 1,5 kg block (3)

3.4.2 Tension in the cord connecting the two blocks (5)

[18]

MOMENTUM

For NSC there will be ±15 marks from this topic. Our target is at least 10 marks.

Momentum - product of object's mass and its velocity.

Principle of conservation of momentum - The total momentum of an isolated system remains constant.

QUESTION 1

State the definition of momentum in words (2)

To answer this question very easily, go to the formulae sheet and look up the formulae for momentum under the heading : FORCE

In order to select the correct formulae, you must know the correct symbols for a specific quantity – learn the different symbols by heart, together with the correct SI-UNIT

Let us complete the following table , before we look at the formulae sheet:

QUANTITY	SYMBOL	SI-UNIT
Momentum		
Mass		
Velocity		

Now select the formulae for momentum and write down in the space below:

Now read what you had written and write it down :

.....

.....

QUESTION 2

The mass of a cricket ball is 156 g and it is bowled at an average velocity of 40,8 $m \cdot s^{-1}$ east.

Calculate the linear momentum of the cricket ball. (3)

SOLUTION:

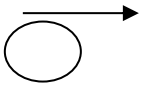
STEP 1

Before starting the problem, read through the problem, at least 3 times.

STEP 2

Analyse the question, if possible, draw a sketch and list the information given.

m = 156 g
v = 40,8 $m \cdot s^{-1}$



The thought process : What must I calculate? Write down the symbol and also what are important things to remember.
p =?

Mass must be in kg – do conversion on list

p and v are vectors, so the answer must include direction

Now, go to formulae sheet and select correct formulae.

Write down formulae, substitute correct values and calculate.

VERY IMPORTANT: Answer must have units and direction

p = mv✓
= 0,156(40,8)✓
= 6,36 $kg \cdot m \cdot s^{-1}$ east ✓ (3)

QUESTION 3

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

Remember this law is not on the formulae sheet – this is something you must memorize, but to help you, do this:
Look at the question: State the *law of conservation of linear momentum* in words.
– There are already clues for you in the question
The words *conservation of linear momentum* must lead you
What is conserved? *Total Momentum*
In what is it conserved? *An isolated system*
All you need to do, is to complete the sentence with the correct words:

The total momentum in an isolated system is conserved/remains constant

QUESTION 4

The diagram below shows a 5 kg block, moving with a velocity of 4 m·s^{-1} to the right, collides head-on with a stationary 3 kg block. After the collision, the two blocks stick together and move to the right.

Calculate the velocity of the combined blocks after collision (5)

SOLUTION

STEP 1

Before starting the problem, read through the problem, at least 3 times.

STEP 2

Analyse the question, list the information given.

m_1 = 5 kg
m_2 = 3 kg

v_1 = 4 m·s^{-1}
v_2 = 0 m·s^{-1}

The thought process : This a collision, so I must apply the law of conservation of linear What must I calculate? Write down the symbol and also what are important things to remember.

v after collision =?

Mass must be in kg

p & v are vectors, so the answer must include direction

Choose direction and right down : right is + , left is -

Write down the law, in symbols, substitute correct values and calculate.

VERY IMPORTANT: Answer must have units and direction

$\sum p_i = \sum p_f$
$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$ } 1 mark for any
$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2)V$

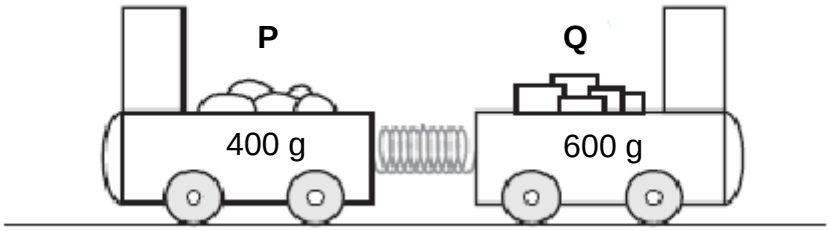
$(5 \times 4) + (3 \times 0) \checkmark = (5 + 3)V \checkmark$
$\therefore V = 2{,}5 \text{ m·s}^{-1} \checkmark$ right ✓

(5)

EXERCISES

QUESTION 1

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.



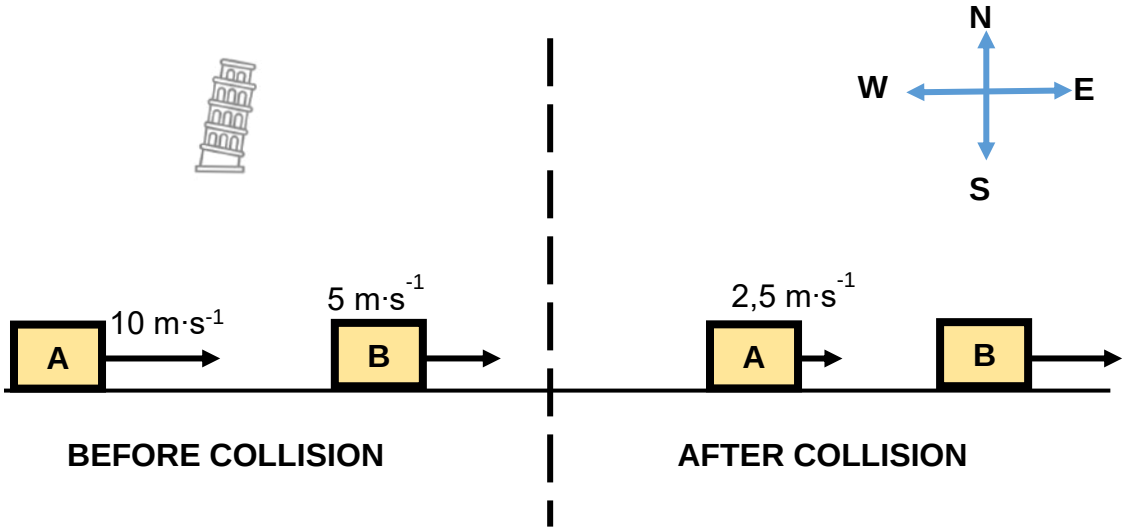
When the trolleys are released, trolley **Q then** moves to the right at 4 m·s^{-1}.

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

1.2 Calculate the velocity of trolley **P** after the trolleys are released (4)
[6]

QUESTION 2

Block **A** of mass 0,20 kg moving east at a speed of 10 m·s^{-1} , collides with another block **B** of mass 0,30 kg, moving east at a speed of 5 m·s^{-1}. After the collision block **A** moves east at a speed of 2,5 m·s^{-1}, as shown in the diagram below.
Ignore the effects of friction.



2.1 State the *law of conservation of linear momentum* in words. (2)

2.2 Calculate the velocity of block **B** after the collision. (5)

[7]

QUESTION 3

Trolley **A** of mass 7,2 kg moves to the right at 0,4 m·s-1 in a straight line on a horizontal floor. It collides with a stationary trolley **B** of mass 5,3 kg.
After the collision, the trolleys lock together and move to the right, as shown in the diagram below.
Ignore any frictional effects.

3.1 Define the term *momentum* in words. (2)

3.2 Calculate the velocity of the trolleys immediately after the collision. (4)

[6]

WORK ENERGY AND POWER

This is a difficult topic. Hence we are focussing only the definitions and free body diagrams that we discussed in Newtons' laws. For NSC there will be ±15 marks from this topic. Our target is 5 marks.

Principle of conservation of mechanical energy

The total mechanical energy in an isolated system remains constant.

Work-energy theorem ($W_{net} = \Delta E_k$)

Net work done on an object is equal to the change in the object's kinetic energy.

Conservative force

A force for which the work done in moving an object between two points is independent of the path taken.
Ex. Gravitational force, elastic force in a spring and electrostatic force.

Non-conservative force

A force for which the work done in moving an object between two points depends on the path taken.
Ex. Friction, tension in a chord.

DOPPLER EFFECT

This is a relatively easy topic. Statement of Doppler effect is a repeated question in almost all the examinations. For NSC there will be ±15 marks from this topic. Our target is at least 8 marks.

Doppler effect : A change in detected frequency, as a result of the relative motion between a source and a listener.

Red shift: Observed when light from an object cause an increase in wavelength (decrease in frequency). A red shift occurs when a light source moves away from an observer. Red shift between different galaxies is a proof that the universe is expanding.

Blue shift: Observed when light from an object cause a decrease in wavelength (increase in frequency). A blue shift occurs when a light source moves towards an observer.

The formula that uses in the problems is: (DO NOT MAKE MISTAKES IN COPYING FROM THE DATA SHEET)

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

USE THIS FORMULA ALWAYS FIRST IN THE PROBLEM
f_L = Frequency of sound that the listener receives.
f_s = Frequency of sound that the source produces.
v_L= Speed of the listener.
v_s= Speed of the source of sound.
v = speed of sound in air.

- When the source and the listener are **approaching**: Here the $f_L > f_s$

  Now the equation is: $f_L = \frac{v + v_L}{v - v_s} f_s$

- When the source and the listener are **moving away**: Here the $f_L < f_s$

  Now the equation is: $f_L = \frac{v - v_L}{v + v_s} f_s$

SOLVED PROBLEMS

QUESTION 1

1.1 The siren of a stationary ambulance emits a note of frequency 1 130 Hz. When the ambulance moves at a constant speed, a stationary observer detects a frequency that is 70 Hz **higher** than that emitted by the siren.

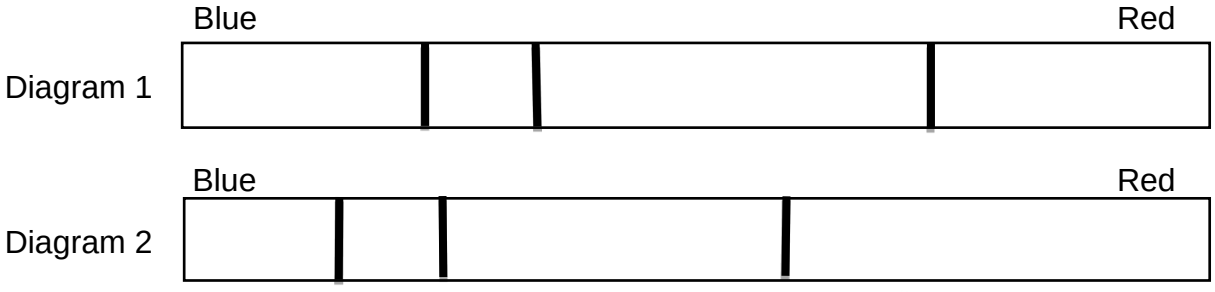
1.1.1 State the Doppler effect in words. (2)

1.1.2 Is the ambulance moving *towards* or *away from* the observer? Give a reason for the answer. (2)

1.1.3 Calculate the speed at which the ambulance is travelling. Take the speed of sound in air as 343 $m \cdot s^{-1}$. (5)

1.2 A study of spectral lines obtained from various stars can provide valuable information about the movement of the stars.

The two diagrams below represent different spectral lines of an element. Diagram **1** represents the spectrum of the element in a laboratory on Earth. Diagram **2** represents the spectrum of the same element from a distant star.



Is the star moving *towards* or *away from* the Earth? Explain the answer by referring to the shifts in the spectral lines in the two diagrams above. (2)

[11]

Solution

1.1.1 A change in detected frequency, as a result of the relative motion between a source and a listener.✓✓ (2)

1.1.2 Here the listener receives a frequency higher than the original frequency. Henec the source is approaching the listener.

Towards✓

Detected frequency is <u>greater than</u> the actual frequency.✓ (2)

1.1.3 Always the copy the formula from the data sheet first.

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$ ✓

Here the source is approaching the listener. So we use the following formula.

$$f_L = \frac{v}{v - v_s} f_s$$ ✓

$$(1200) = \frac{343}{343 - v_s} 1130$$ ✓

v_s = 20,01 m·s^{-1}✓

f_s = 1130 Hz
f_L = 1130 +70 = 1200 Hz
v_L= 0 (Listener is at rest)
v = 343 m·s^{-1}
v_s= ?

(5)

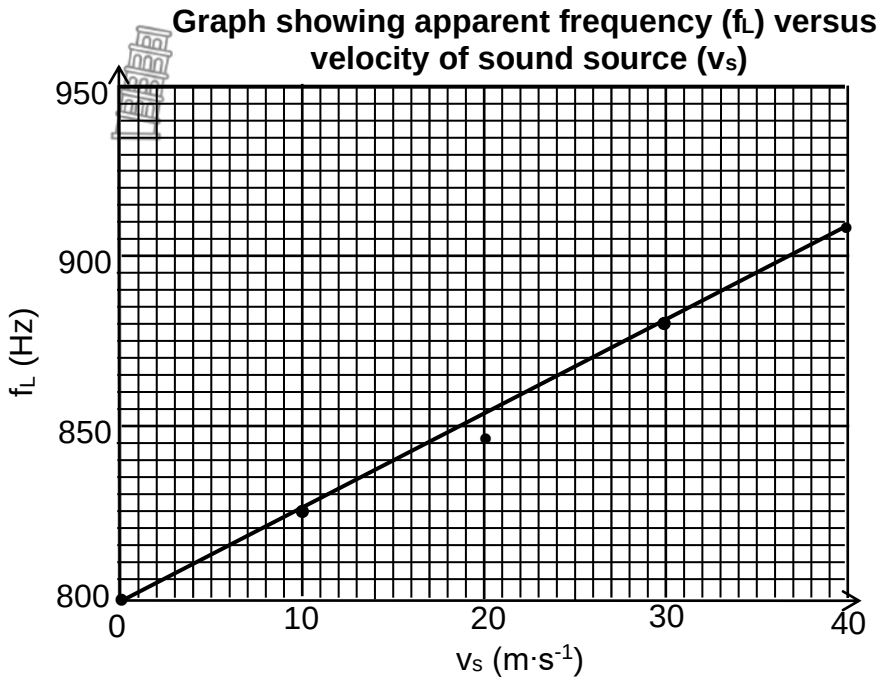
1.2 Look where the spectrum is shifting towards. It is shifting towards the blue region.

The star is approaching the earth. ✓
OR
The earth and the star are approaching (moving towards) each other.✓

The spectral lines in diagram 2 are shifted towards the blue end/blue shifted.✓ (2)
[11]

QUESTION 2

The graph below shows the relationship between the apparent frequency (f_L) of the sound heard by a STATIONARY listener and the velocity (v_s) of the source travelling TOWARDS the listener.



2.1 Use the information in the graph to calculate the speed of sound in air. (5)

2.2 Sketch a graph of apparent frequency (f_L) versus velocity (v_s) of the sound source if the source was moving AWAY from the listener. It is not necessary to use numerical values for the graph. (2)

[7]

Solution

2.1 Here we need to read all the data from the graph. Source frequency is the frequency when the speed of the source is 0. So f_s = 800 Hz
Question says that listener is stationary. So $v_L = 0$
Now there are different speeds for the source that we can read from the x-axis of the graph. But remember that the listener frequency (f_L) changes with the speed of the source(v_S)
Look at the Y-axis of the graph. First reading is 800 Hz and the next after 10 divisions is 850 Hz. So 10 divisions is 50
Or 1 division = 5 Hz
Let us take $v_S = 10\ m\cdot s^{-1}$ then from the graph you can see there are 5 divisions on the Y-axis.
So f_L = 800 Hz + 5 divisions
= 800 + 5 x 5 = 825 Hz

So the general formula is

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$

Here the source is approaching the stationary listener $v_L = 0$. So we use the following formula.

$$f_L = \frac{v}{v - v_s} f_s \checkmark$$

$$825 = \frac{v}{v - 10} (800) \checkmark$$

$$\frac{825}{800} = \frac{v}{v - 10}$$

$$1{,}031 = \frac{v}{v - 10}$$

$(1{,}031)(v - 10) \checkmark = v$

$1{,}031\ v - 10 = v$

$1{,}031\ v - v = 10$

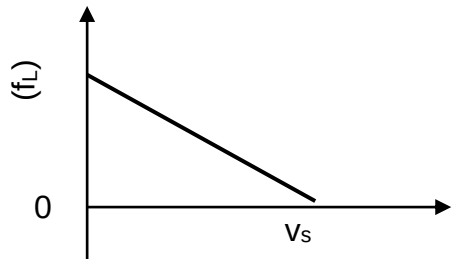
$0{,}031v = 10$

$$v = \frac{10}{0{,}031}$$

$\therefore\ v = 322{,}58\ m \cdot s^{-1} \checkmark.$ (5)

2.2 The graph in the question is when the source is moving TOWRARDS the listener. Then f_L increases.
Now the question is asking for the graph when the source is moving AWAY. Here f_L decreases.

Straight line with negative gradient



(2)
[7]

EXERCISES

QUESTION 1

1.1 The data below was obtained during an investigation into the relationship between the different velocities of a moving sound source and the frequencies detected by a stationary listener for **each** velocity. The effect of wind was ignored in this investigation.

Experiment number	1	2	3	4
Velocity of the sound source ($m \cdot s^{-1}$)	0	10	20	30
Frequency (Hz) of the sound detected by the stationary listener	900	874	850	827

1.1.1 Write down the dependent variable for this investigation. (1)

1.1.2 State the Doppler effect in words. (2)

1.1.3 Was the sound source moving TOWARDS or AWAY FROM the listener? Give a reason for the answer. (2)

1.1.4 Use the information in the table to calculate the speed of sound during the investigation. (5)

1.2 The spectral lines of a distant star are shifted towards the longer wavelengths of light. Is the star moving TOWARDS or AWAY FROM the Earth? (1)
[11]

QUESTION 2

2.1 An ambulance is moving towards a stationary listener at a constant speed of 30 $m \cdot s^{-1}$. The siren of the ambulance emits sound waves having a wavelength of 0,28 m. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

2.1.1 State the Doppler effect in words. (2)

2.1.2 Calculate the frequency of the sound waves emitted by the siren as heard by the ambulance driver. (3)

2.1.3 Calculate the frequency of the sound waves emitted by the siren as heard by the listener. (5)

2.1.4 How would the answer to QUESTION 2.1.3 change if the speed of the ambulance were LESS THAN 30 $m \cdot s^{-1}$? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

2.2 An observation of the spectrum of a distant star shows that it is moving away from the Earth.

Explain, in terms of the frequencies of the spectral lines, how it is possible to conclude that the star is moving away from the Earth. (2)

[13]

QUESTION 3

The Doppler effect is applicable to both sound and light waves. It also has very important applications in our everyday lives.

3.1 A hooter on a stationary train emits sound with a frequency of 520 Hz, as detected by a person standing on the platform. Assume that the speed of sound is 340 $m \cdot s^{-1}$ in still air.

Calculate the:

3.1.1 Wavelength of the sound detected by the person (2)

3.1.2 Wavelength of the sound detected by the person when the train moves towards him/her at a constant speed of 15 $m \cdot s^{-1}$ with the hooter still emitting sound (6)

3.2 Explain why the wavelength calculated in QUESTION 3.1.1 differs from that obtained in QUESTION 3.1.2. (2)

3.3 Use your knowledge of the Doppler effect to explain *red shifts.* (2)

[12]

ELECTROSTATICS

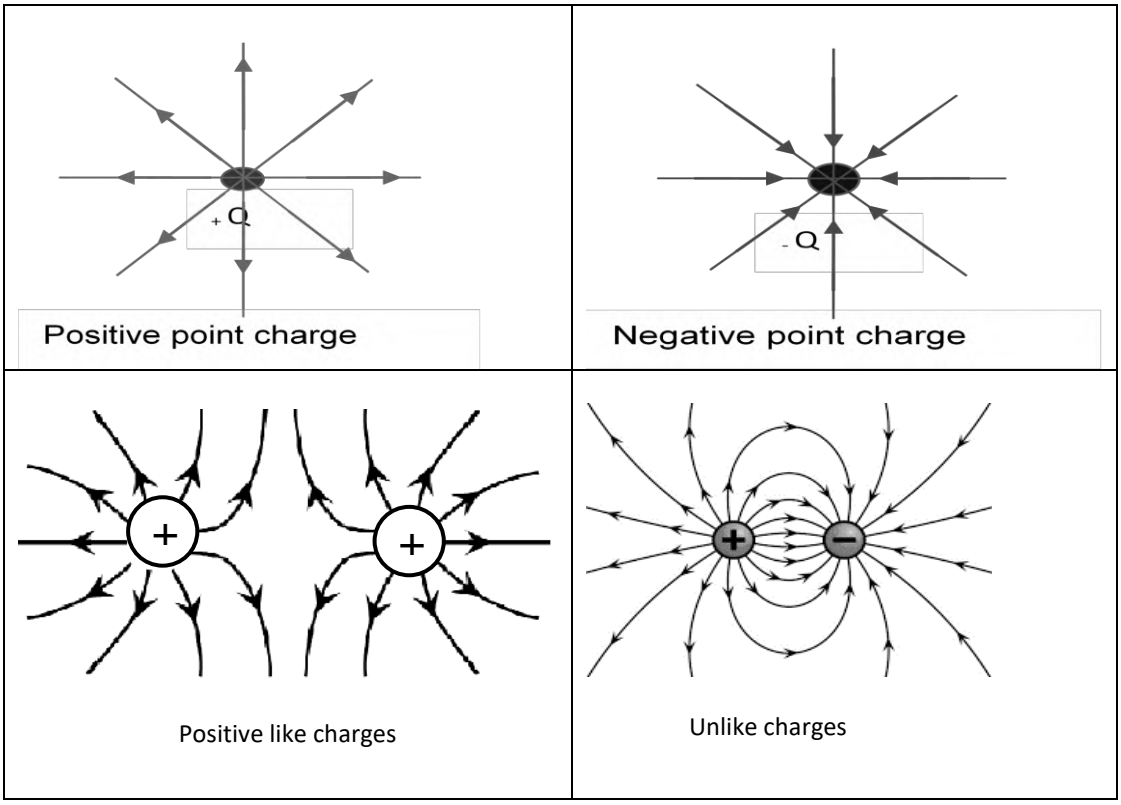
This is a relatively easy Grade 11 topic. For NSC there will be ±20 marks from this topic. Our target is at least 10 marks.

Coulombs law - The electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them.

Electric field - is an area of space in which an electric charge experiences a force.

Electric field at a point - is the electrostatic force experienced per unit positive charge placed at that point.

Electric field patterns



QUESTION 1

State the definition of *electric field at a point* in words. (2)

To answer this question very easily, go to the formulae sheet and look up the formulae for electric field at a point under the heading : ELECTROSTATICS

In order to select the correct formulae, you must know the correct symbols for a specific quantity – learn the different symbols by heart, together with the correct SI-UNIT

Let us complete the following table , before we look at the formulae sheet:

QUANTITY	SYMBOL	SI-UNIT
Electric field		
Electric force		
Unit charge		

Now select the formulae for *Electric field at a point* and write down in the space below:

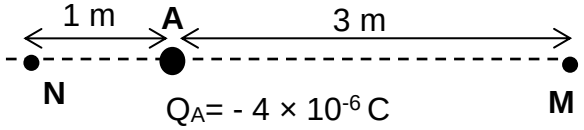
Now read what you had written and write it down :

.....

.....

QUESTION 2

The diagram below shows a point charge **A** with a charge of - 4×10^{-6} C and two points **M** and **N.**



2.1 Define *electric field* in words

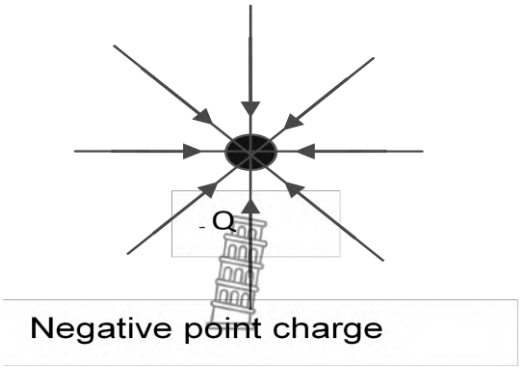
Remember this definition is not on the formulae sheet – this is something you must memorize, but to help you, do this:

Look at the question: Define *electric field* in words

– There are already clues for you in the question
The words *electric field* must lead you – without at a point, so must be the area of space

Electric field - is an area of space in which an electric charge experiences a force. (2)

2.2 Draw the electric field pattern due to point charge **A.**



✓ Correct form (lines must touched surface, lines must not cross)

✓ Direction

(2)

2.3 A positive point charge **B** with charge + 8 x 10^{-6} C is placed at point **M.** Point charges **A** and **B** exerts forces on each other.

2.3.1 State *Coulomb's law* in words.

To answer this question very easily, go to the formulae sheet and look up the formulae for electric field at a point under the heading : ELECTROSTATICS

In order to select the correct formulae, you must know the correct symbols for a specific quantity – learn the different symbols by heart, together with the correct SI-UNIT

Let us complete the following table , before we look at the formulae sheet:

QUANTITY	SYMBOL	SI-UNIT
Electric force		
Charge		
Distance		

Now select the formulae for *Coulomb's law* and write down in the space below:

Now read what you had written and write it down :

……

……

……

……

(2)

2.3.2 Calculate the electrostatic force exerted by charge **A** on charge **B.** (4)

SOLUTION

STEP 1

Before starting the problem, read through the problem, at least 3 times.

STEP 2

Analyse the question, list the information given.

$Q_A = -4 \times 10^{-6}\,C$
$Q_B = +8 \times 10^{-6}\,C$
$d = 3\,m$

The thought process : I must apply Coulomd's law. What must I calculate? Write down the symbol and also what are important things to remember.

F =?

Charge must be in C

Distance must be in m

F is a vector : answer must have SI-unit and direction

STEP 3

Go to formulae sheet and select correct formulae, substitute and calculate

VERY IMPORTANT: Do not substitute negative sign into Coulomb's law

$$F_{AB} = \frac{KQ_AQ_B}{r^2} \checkmark$$

$$F_{AB} = \frac{9 \times 10^9 \times (4 \times 10^{-6} \times (8 \times 10^{-6}) \checkmark}{(3)^2 \checkmark}$$

$F_{AB} = 0{,}032\ N$. Towards point charge A ✓

3.3.3 Calculate the net electric field at point N.

SOLUTION

STEP 1

Before starting the problem, read through the problem, at least 3 times.

STEP 2

Analyse the question, list the information given.

$Q_A = -4 \times 10^{-6}\,C$
$Q_B = +8 \times 10^{-6}\,C$
$d_1 = 3\,m$
$d_2 = 3\,m + 1\,m$

The thought process : What must I calculate? Write down the symbol and also what are important things to remember.

Enet =?

Charge must be in C

Distance must be in m

Enet is a vector : answer must have SI-unit and direction

STEP 3

Draw a vector diagram for two different Electric fields

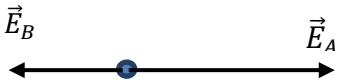
STEP 4

Go to formulae sheet and select correct formulae, substitute and calculate

VERY IMPORTANT: Do not substitute negative sign formulae of electric field

HINT : Do calculations separately : Enet is the vector sum of the two Electric fields(direction is important)

Choose sign for directions

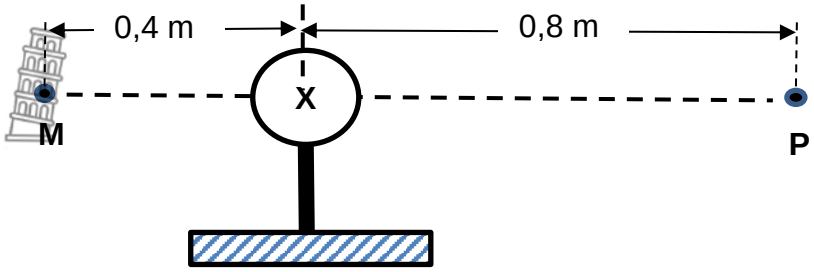


OPTION 1	**OPTION 2**	
Positive towards point charge A: $E = K\frac{Q}{r^2}$✓ $E_A = 9 \times 10^9 \frac{(4\times10^{-6})}{1^2}$✓ $E_A = 3{,}6 \times 10^4\ N \cdot C^{-1}$ $E_B = 9 \times 10^9 \frac{(8\times10^{-6})}{4^2}$✓ $E_B = 4{,}5 \times 10^3\ N \cdot C^{-1}$ $\vec{E}_{net} = \vec{E}_A + \vec{E}_B$ $E_{net} = E_A - E_B$ $E_{net} = 3{,}6 \times 10^4 - 4{,}5 \times 10^3$ ✓ $E_{net} = +3{,}15 \times 10^4\ N \cdot C^{-1}$✓ **OR** $E_{net} = 3{,}15 \times 10^4\ N \cdot C^{-1}$ towards charge A	Positive towards point charge B: $E = K\frac{Q}{r^2}$✓ $E_A = 9 \times 10^9 \frac{(4\times10^{-6})}{1^2}$✓ $E_A = 3{,}6 \times 10^4\ N \cdot C^{-1}$ $E_B = 9 \times 10^9 \frac{(8\times10^{-6})}{4^2}$✓ $E_B = 4{,}5 \times 10^3\ N \cdot C^{-1}$ $\vec{E}_{net} = \vec{E}_A + \vec{E}_B$ $E_{net} = E_A - E_B$ $E_{net} = -3{,}6 \times 10^4 + 4{,}5 \times 10^3$ ✓ $E_{net} = -3{,}15 \times 10^4$ ✓ **OR** $E_{net} = 31{,}5 \times 10^5\ N \cdot C^{-1}$ towards charge A✓	(5) **[15]**

EXERCISES

QUESTION 1

The diagram below shows a metal sphere **X** of negligible mass on an insulated stand in a vacuum. 3,125 x 10^{10} electrons have been removed from the sphere.



1.1 Draw the electric field pattern associated with sphere **X**. (2)

1.2 Describe an *electric field*. (2)

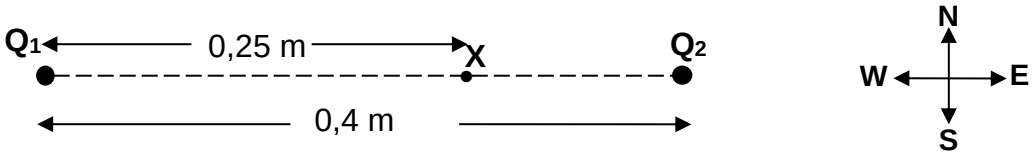
1.3 Calculate the net charge on the sphere. (3)

1.4 Calculate the electric field at point **P**. (3)

[10]

QUESTION 2

Two charged particles, Q_1 and Q_2, are placed 0,4 m apart along a straight line. The charge on Q_1 is + 2 μC, and the charge on Q_2 is – 8 μC. Point **X** is 0,25 m **east** of Q_1, as shown in the diagram below.



2.1 Draw the electric field pattern because of charged particles Q_1 and Q_2 (3)

Calculate the:

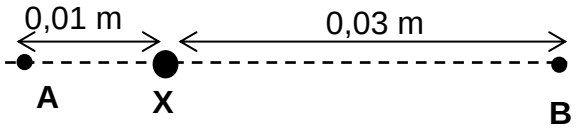
2.2 Net electric field at point **X** due to the two charges (6)

2.3 Net electrostatic force that a – 2 nC charge will experience at point **X** (4)

[10]

QUESTION 3

The diagram below shows a small sphere **X** from which 938 electrons were removed and two points **A** and **B** at different distances from the sphere **X.**



3.1 What is the nature of the charge on sphere **X**? Choose from POSITIVE or NEGATIVE. (1)

3.2 Calculate the magnitude of the charge on sphere **X**. (3)

3.3 Define *electric field at a point* in words (2)

3.4 Draw the electric field pattern around sphere **X.** (2)

3.5 At what point, **A** or **B,** is the magnitude of the electric field due to the charged sphere **X** greater? Explain the answer. (3)

3.6 A negative point charge **Y** with charge -2,8 x 10^{-16} C is NOW placed at point **B** and a point charge **Z** with charge +3,2 x 10^{-16} C is placed at point **A.**

3.6.1 State *Coulomb's law* in words. (2)

3.6.2 Calculate the net electrostatic force on sphere **X.** (5)

[18]

ELECTRODYNAMICS

For NSC there will be ±15 marks from this topic. Our target is at least 5 marks.

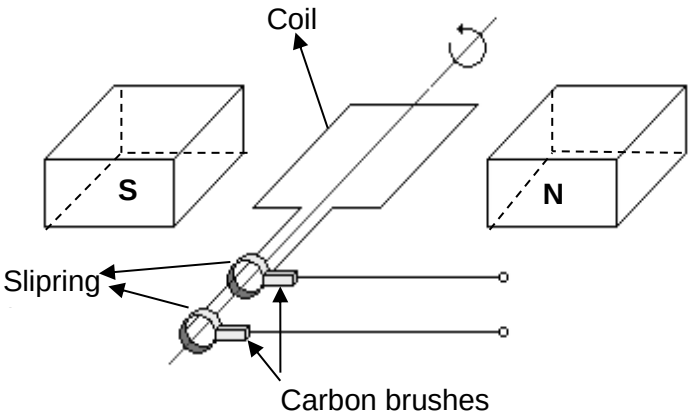
1. GENERATORS

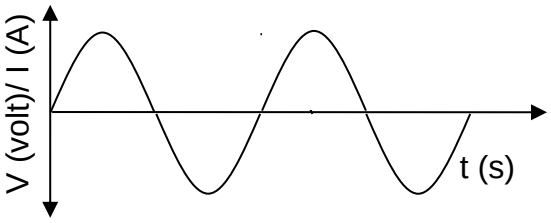
Generator convert mechanical energy to electrical energy.

They work on the *principle of electromagnetic induction*.

There are 2 types: AC and DC generator.

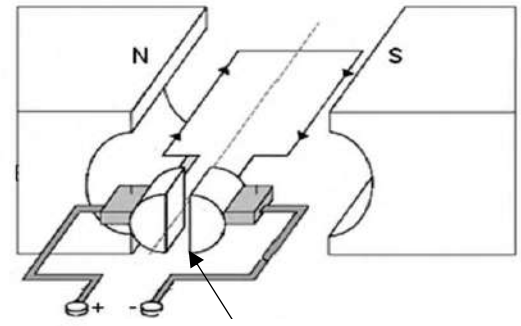
AC GENERATOR



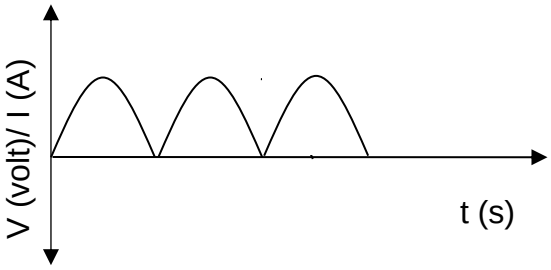


The output voltage or current of AC generator

DC GENERATOR



Split rings (commutator)



The output voltage or current of DC generator

The current can be increased by:

- Increase the number of turns in the coil
- Increase the area of the coil
- Use a strong magnet.

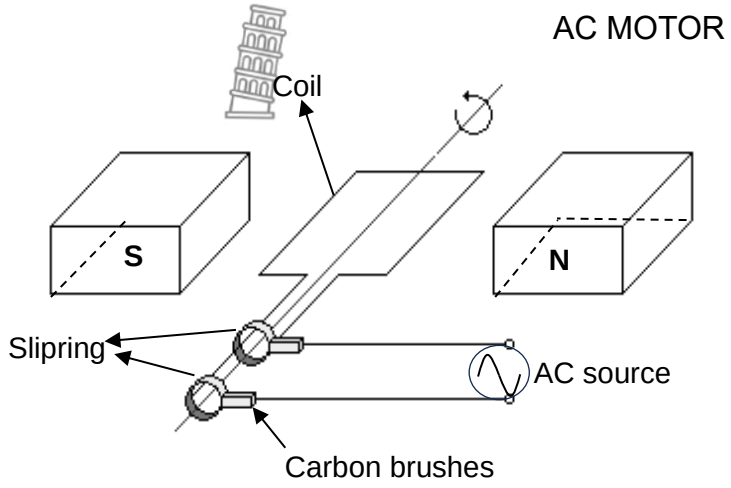
2. MOTORS

Motors convert electrical energy to mechanical energy.

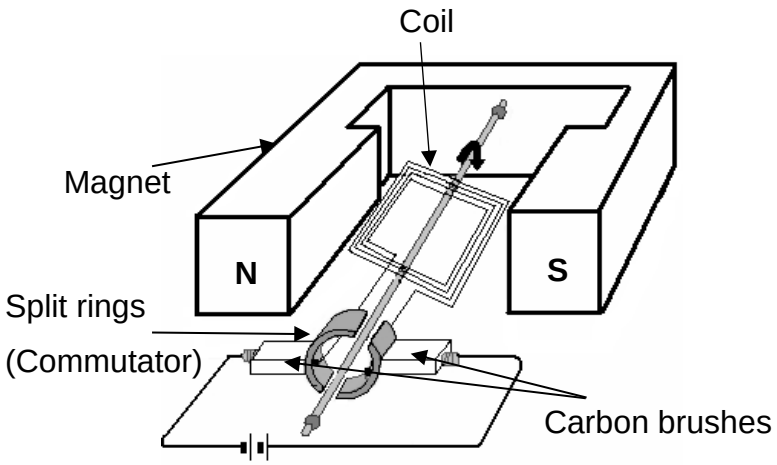
It works on the principle of motor effect.

There are 2 types. AC and DC motor.

AC MOTOR



DC MOTOR



RMS voltage(current)- The rms potential difference (current) is the DC potential difference (current)which dissipates/produces the same amount of energy as an equivalent AC potential difference (current).

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \frac{I_{maks}}{\sqrt{2}}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \frac{V_{maks}}{\sqrt{2}}$	$P_{average} = V_{rms} I_{rms}$ *or/of* $P_{gemiddeld} = V_{wgk} I_{wgk}$ $P_{average} = I_{rms}^2 R$ *or/of* $P_{gemiddeld} = I_{wgk}^2 R$ $P_{average} = \frac{V_{rms}^2}{R}$ *or/of* $P_{gemiddeld} = \frac{V_{wgk}^2}{R}$

WORKED EXAMPLES

QUESTION 1

AC generators at coal-fired power stations supply most of the electrical energy needed in our country.

1.1 State ONE structural difference between an AC and a DC generator. (2)

A certain AC generator (alternator) produces a peak current (I_{max}) of 6,43 A when connected to an electrical heater of resistance 48,4 Ω.

1.2 Calculate the rms current (I_{rms}) produced by the generator. (3)

1.3 Calculate the peak voltage (V_{max}) output of the generator. (3)

1.4 Draw a sketch graph of potential difference versus time for this AC generator. Clearly label the axes and indicate V_{max} on the potential difference axis. (2)

[10]

Solution

1.1 Look in the diagrams of both generators. AC generator has slip rings and DC generator has split rings.
AC generator – slip rings✓
DC generator – (split ring) commutator✓ (2)

1.2 From the question:
I_{max} = 6,43 A
I_{rms} = ?
Look for the equation connecting it.

$$I_{rms} = \frac{I_{max}}{\sqrt{2}} \checkmark$$

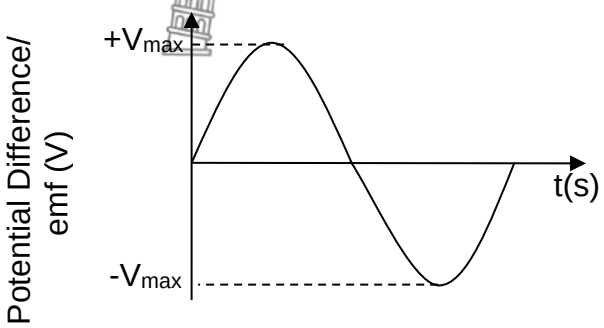
$$= \frac{6,43}{\sqrt{2}} \checkmark$$

=4,55 A✓ (3)

1.4 We can use the equation V = IR
But do not forget to write the subscripts. So:
$V_{max} = I_{max}R$✓
= (6,43)(48,4) ✓
= 311,21 V✓

(3)

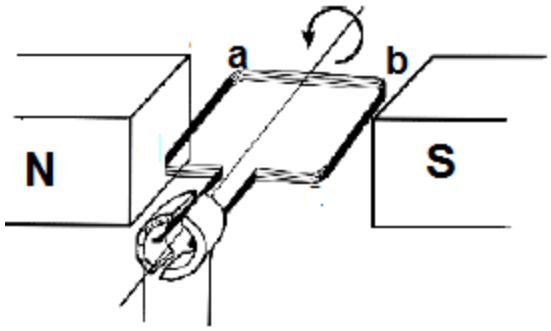
1.5 It is an AC generator . So the shape will be a sine wave.



(2)
[10]

QUESTION 2

2.1 A part of a simplified DC motor is shown in the sketch below.



2.1.1 Which component in the diagram must be replaced in order for the device to operate as an AC generator? (1)

2.2 An electrical device of resistance 400 Ω is connected across an AC generator that produces a maximum emf of 430 V. The resistance of the coils of the generator can be ignored.

2.2.1 State the energy conversion that takes place when the AC generator is in operation. (2)

2.2.2 Calculate the root mean square value of the current passing through the resistor. (5)
[8]

Solution

2.1 Given diagram is a DC motor and has SPLIT rings. An AC generator must have SLIP rings.
Split rings /commutator ✓ (1)

2.2.1 Mechanical/Kinetic energy to electrical energy. ✓✓
Meganiese /kinetiese energie na elektriese energie (2)

2.2.2 From the question:
V_{max} = 430 V
R = 400 Ω
I_{rms} = ?
First we need to find the V_{rms}

$$V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$$

$$= \frac{430}{\sqrt{2}} \checkmark$$

$$= 304,06 \text{ V}$$

Now we can find the I_{rms} using the equation below.

$$I_{rms} = \frac{V_{rms}}{R} \checkmark$$

$$= \frac{304,06}{400} \checkmark$$

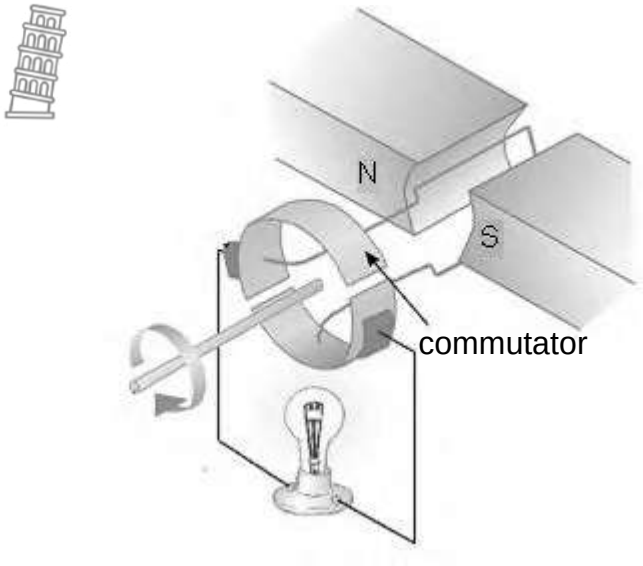
$$= 0,76 \text{ A} \checkmark$$

(5)
[8]

EXERCISES

QUESTION 1

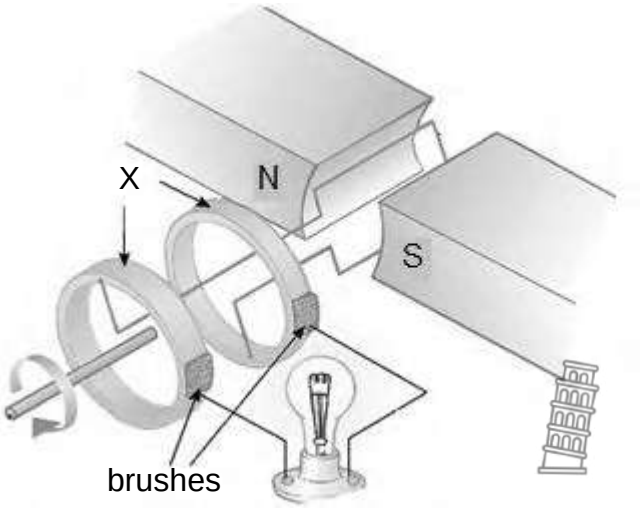
The diagram below represents a simplified version of an electrical machine used to light up a bulb.



1.1 Name the principle on which the machine operates. (1)

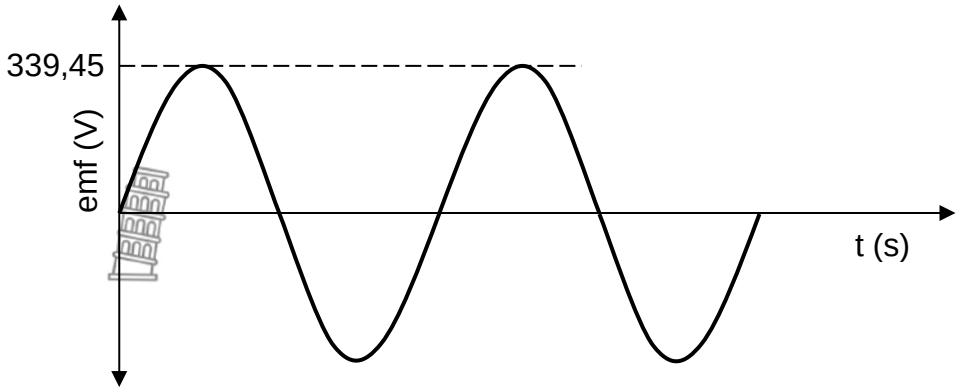
1.2 State ONE way in which to make this bulb burn brighter. (1)

Some changes have been made to the machine and a new device is obtained as shown below.



1.3 Name part **X** in the new device. (1)

1.4 The graph of output emf versus time obtained using the device in QUESTION 1.3 is shown below.

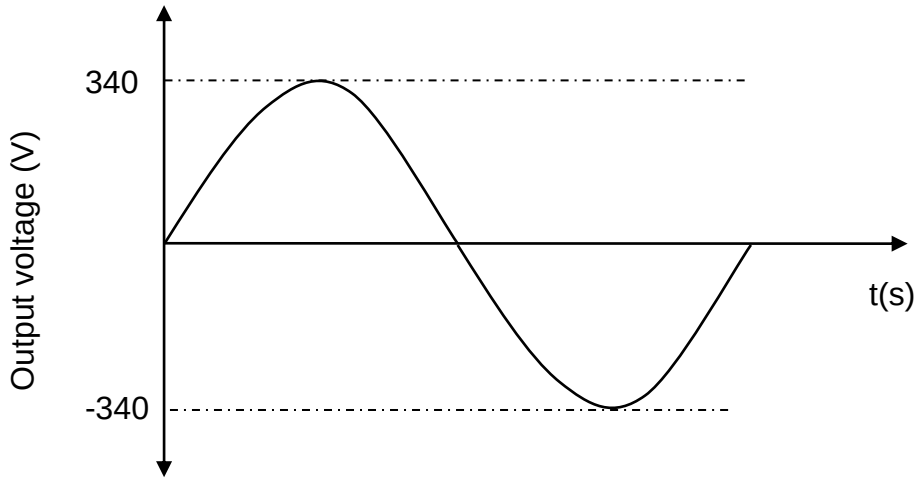


1.4.1 Define the term *root mean square value* of an AC voltage. (2)

1.4.2 Calculate the rms voltage. (3)
[8]

QUESTION 2

The graph below shows the output voltage from a household AC generator for one cycle of rotation of the coils.



2.1 A 100 W light bulb is connected to this generator and it glows at its maximum brightness. Use the information from the graph to calculate the:

2.1.1 Resistance of the bulb (5)

2.1.2 rms current through the bulb (3)
[8]

P2 CHEMISTRY

ORGANIC CHEMISTRY

This is a very important topic. For NSC there will be 60 marks from this section. You need to get at least 30 marks.

1. NOMENCLATURE

Hydrocarbon: Organic compounds that consist of hydrogen and carbon only.

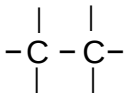
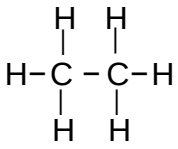
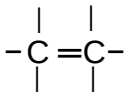
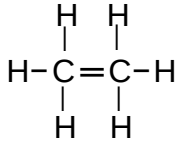
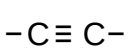
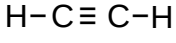
Homologous series: A series of organic compounds that can be described by the same general formula.

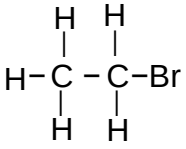
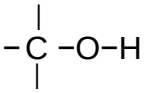
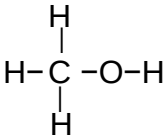
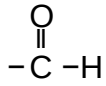
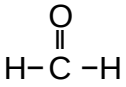
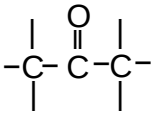
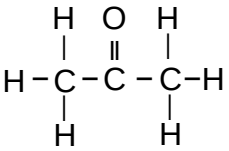
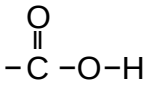
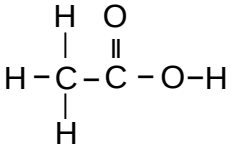
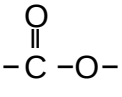
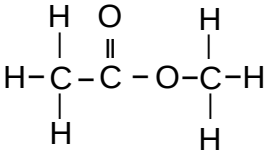
Saturated compounds: Compounds in which there are no multiple bonds between C atoms.

Unsaturated compounds: Compounds with multiple bonds between C atoms.

Functional group: A bond or an atom or a group of atoms that determines the physical and chemical properties of a group of organic compounds.

Homologous series, general formula and functional group

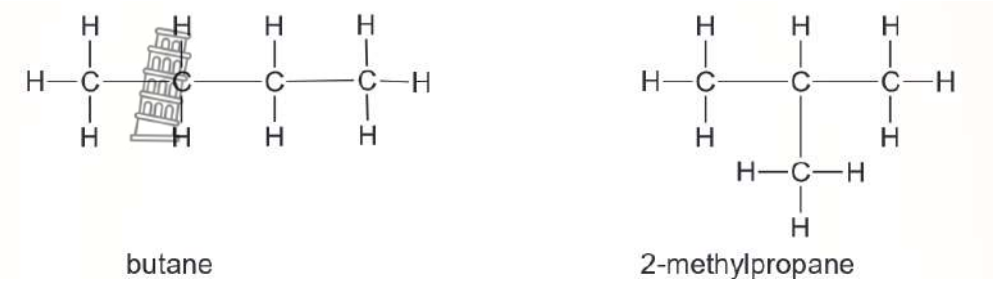
Homologous series		General formula	Structural formula of functional group	Name ending	Structural formula of example
Hydrocarbons	Alkanes	C_nH_{2n+2}		-ane	 Ethane
	Alkene	C_nH_{2n}		-ene	 Ethene
	Alkyne	C_nH_{2n-2}		-yne	 Ethyne

Homologous series	General formula	Structural formula of functional group	Name ending	Structural formula of example
Haloalkane	**C_nH_{2n+1}-X**		**halo-ane** **(except when there are substituents)**	 **Bromoethane**
Alcohol	**C_nH_{2n+1}-OH** **or** **R-OH**		**-ol**	 **Methanol**
Aldehyde	**$C_nH_{2n}O$** **or** **R-CO-H**		**-al**	 **Methanal**
Ketone	**$C_nH_{2n}O$** **or** **R-CO-R'**		**-one**	 **Propanone**
Carboxylic acid	**C_nH_{2n+1}-COOH** **or** **R-COOH**		**-oic acid**	 **Ethanoic acid**
Ester	**R-COO-R'**		**-oate**	 **Methylethanoate**

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

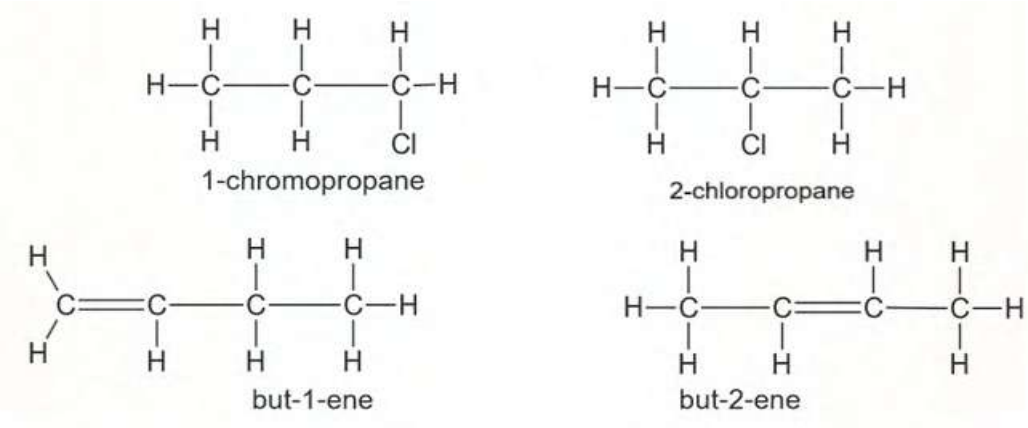
Chain isomers: Compounds having same molecular formula, but different types of chains.

e.g.butane and 2-methylpropane.



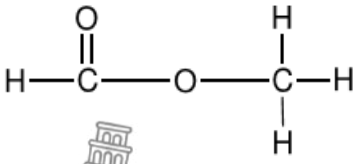
Positional isomers: Compounds having same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain.

e.g. 1-choropropane and 2-chloropropane or but-2-ene and but-1-ene

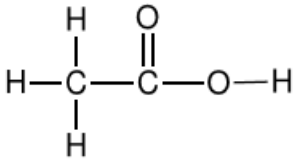


Functional isomers: Compounds having same molecular formula, but different functional groups,

e.g. methyl methanoate and ethanoic acid



methyl methanoate



ethanoic acid

Carboxilic acids and **esters** are functional isomers.	A**ldehydes** and **ketones** are functional isomers.

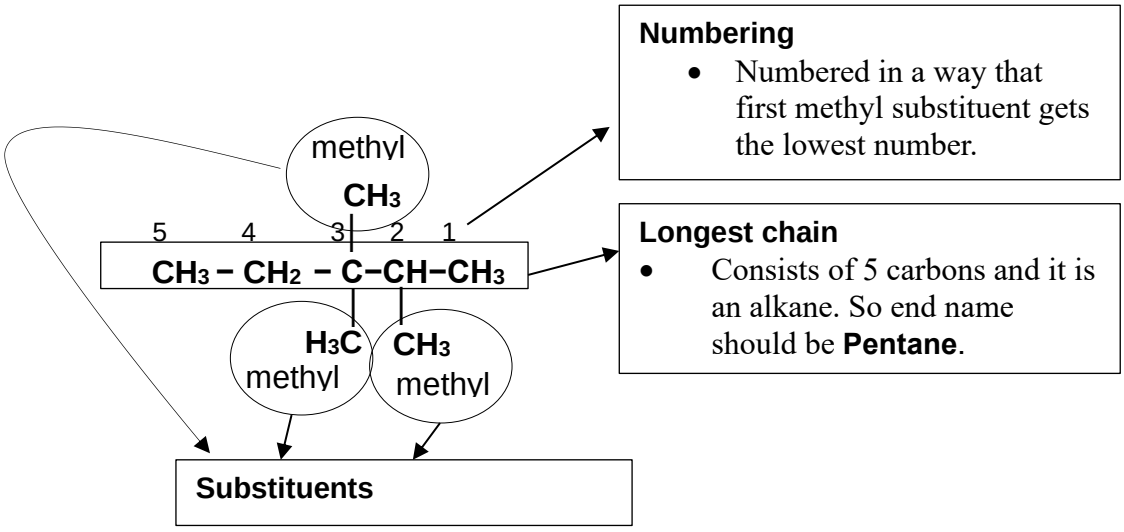
Primary alcohol: C-atom carrying the hydroxyl group is attached to only ONE another carbon atom.

Secondary alcohol: C-atom carrying the hydroxyl group is attached to TWO other carbon atoms.

Tertiary alcohol: C-atom carrying the hydroxyl group is attached to THREE other carbon atoms.

EXAMPLES FOR NAMING

Example 1



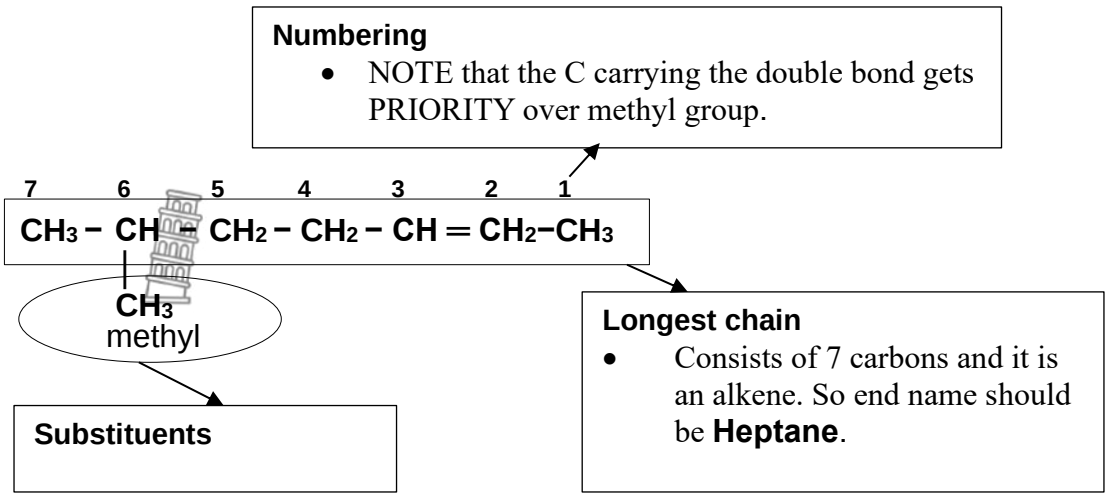
- One methyl substituent at position 2.
- Two methyl substituents at positions 3

So it should be: **2,3,3-trimethyl** (tri is used as there are 3 methyl substituents)

The IUPAC name is:

2,3,3-trimethylpentane

Example 2

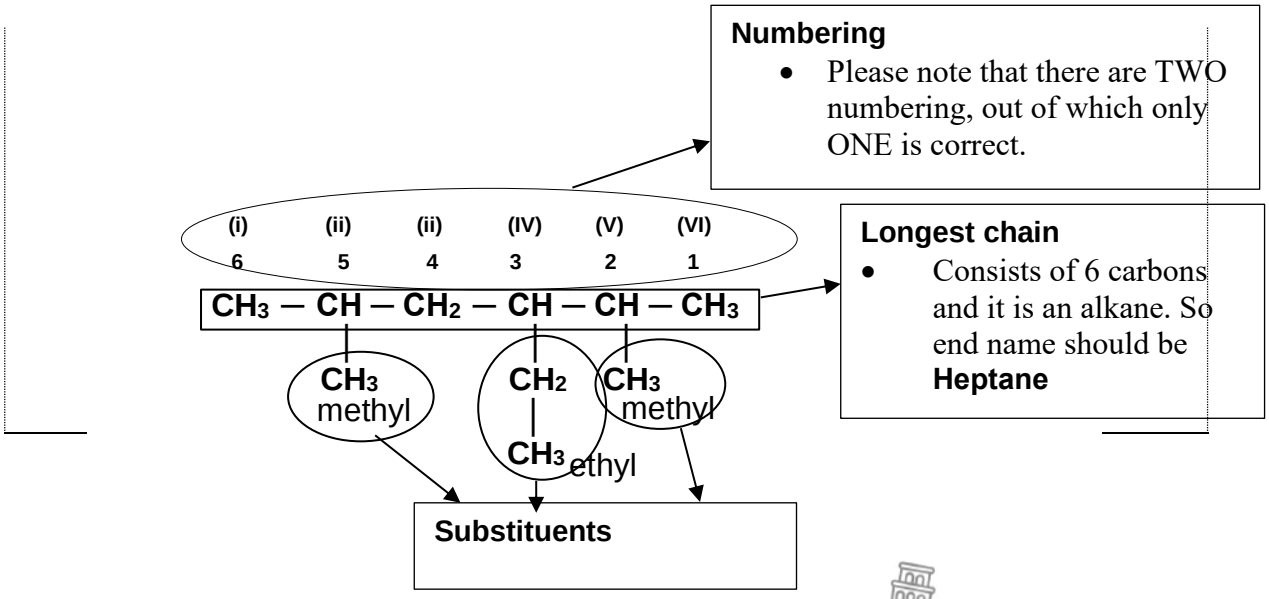


- Only one methyl substituent at position 6.
  So it should be: **6-methyl**

As the doble bond is on the second carbon the IUPAC name is:

6-methylhept-2-ene

Example 3



<u>Following normal numbering</u> (1-6)

- Methyl substituents at positions 2 and 5 → 2,5-dimethyl
- and ethyl at position 3. → 3-ethyl
- E (ethyl) comes first before M (methyl)→ So it should be: **3-ethyl-2,5-dimethyl**

So the IUPAC name is
3-ethyl-2,5-dimethylhexane

Following Roman numbering (i-VI)

- Still methyl substituents at positions (ii) and (v) → 2,5-dimethyl

But ethyl at position (iv). → 4-ethyl

So it should be: **4-ethyl-2,5-dimethyl**

So the IUPAC name is

4-ethyl-2,5-dimethylhexane

Now take the sum of the numbers-

In **3-ethyl-2,5-dimethylhexane**, **3**+2+5 = 10

In **4-ethyl-2,5-dimethylhexane**, 4+2+5 = 11

IUPAC rule states that we need to take the lowest:

So the correct IUPAC name of the above compound is:

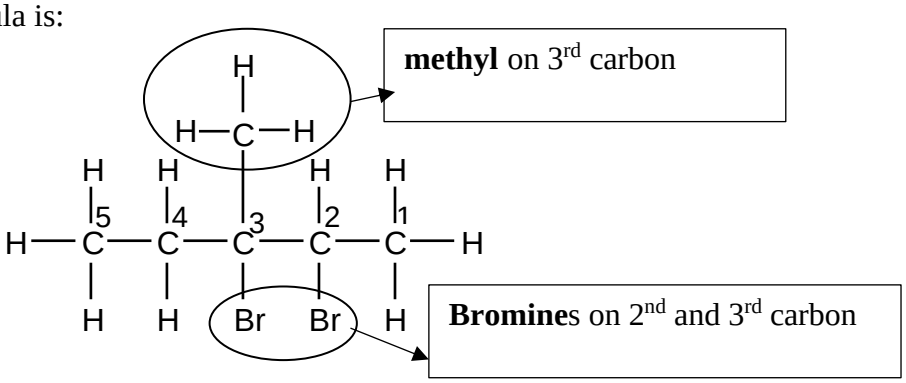
3-ethyl-2,5-dimethylhexane

Example 4

Write down the structural formula of 2,3-dibromo-3-methylpentane

The end name is Pentane. So there should be 5 carbons in the long chain.
There should be TWO bromines (dibromo) on the second and third carbons(2,3-dibromo).
There should be One methyl on the third carbon (3-methyl)

So the structural formula is:



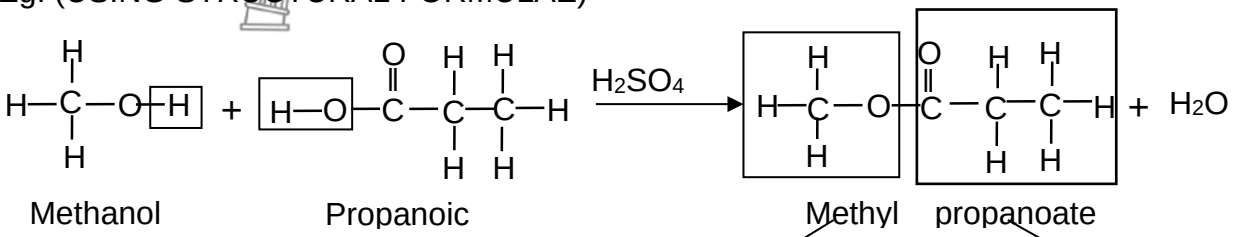
ESTERIFICATION

Esters form when an **alcohol** reacts with a **carboxylic acid** when **heated** in the presence of Conc. H_2SO_4. The reaction whereby esters is formed is called **esterification**

Reactants: Alcohol + carboxylic acid **Products:** Ester + water

Conditions: Con. H_2SO_4 as catalyst and heat

Eg. (USING STRUCTURAL FORMULAE)



Methanol Propanoic Methyl propanoate

First part of the name comes from the alcohol

End name comes from the carboxylic

Eg. (USING CONDENSED STRUCTURAL FORMULAE)

$$CH_3OH + CH_3CH_2COOH \xrightarrow[\text{Heat}]{H_2SO_4} CH_3CH_2COOCH + H_2$$

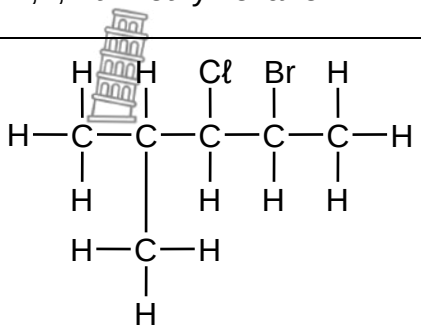
Methanol Propanoic Methylpropanoate

NOTE: Esters are known for their pleasant smell and hence used in perfumes and used as artificial flavours.

WORKED EXAMPLE

QUESTION 1

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

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

1.1 Write down the LETTER that represents the following:

1.1.1 An aldehyde (1)

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

1.2 Write down the IUPAC name of compound **C**. (3)

1.3 Write down the structural formula of:

1.3.1 Compound **A** (2)

1.3.2 Compound **D** (2)

1.4 The table contains compounds which are functional isomers.

1.4.1 Define the term *functional isomer*. (2)

1.4.2 Write down the LETTERS that represent two compounds that are functional isomers. (1)

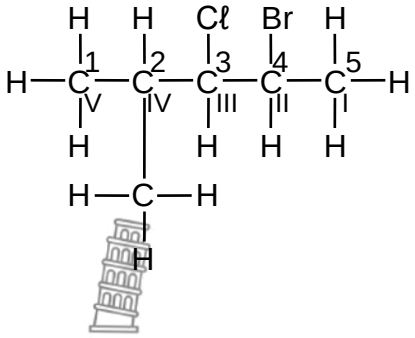
[12]

Solution

1.1.1 Aldehyde end with -CHO in molecular formula. Hence answer is: (1)
B ✓

1.1.2 Carbonyl group is found in a ketone that ends the name with -one. Hence answer is: (1)
D ✓

1.2



Numbering 1-5
Methyl on 2nd carbon
Chlorine on 3rd carbon
Bromine on 4th carbon
So the name is:
4-bromo-3-chloro-2-methylpentane
Total is 4+3+2 = 9

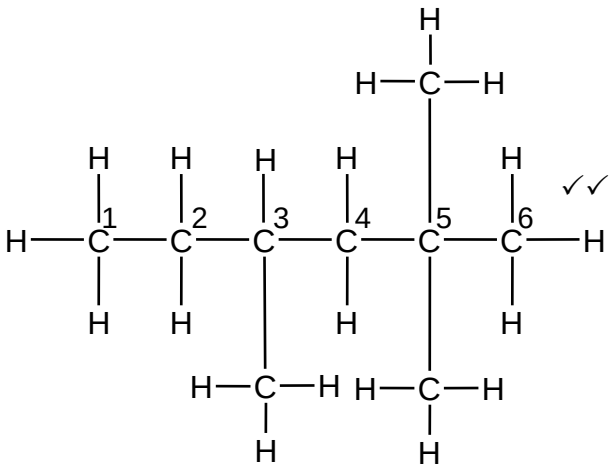
Numbering I-V
Bromine on 2nd carbon
Chlorine on 3rd carbon
Methyl on 4th carbon
So the name is:
2-bromo-3-chloro-4-methylpentane
Total is 4+3+2 = 9

In both cases the total remains the same. Now let us look at the alphabetic order. B (bromine) should get the lowest number. So the correct answer is:
2-bromo-3-chloro-4-methylpentane

(3)

1.3

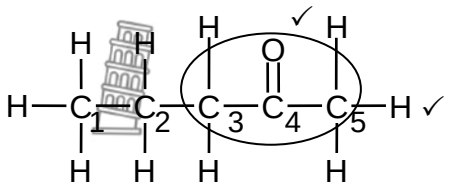
1.3.1 2,2,4-trimethylhexane
3 methyl groups.
Two on the second and one on the 4th carbon.
So the structural formula is:



✓✓

(2)

1.3.2 Pentan-2-one
Due to pentan, there will be 5 carbons in the straight chain.
-one says that this is a ketone (functional group is carbonyl).
Carbonyl is on the second carbon.
So the structural formula is:



(2)

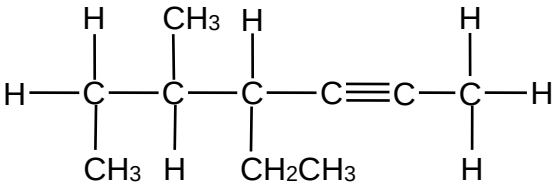
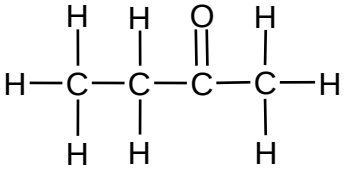
1.4
1.4.1 (Compounds with) the same molecular formula ✓ but different functional goups / different homologous series. ✓ (2)

1.4.2 Ketone and aldehydes are functional isomers. So answer is: (1)
B & D ✓ **[12]**

EXERCISES

QUESTION 1

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.

1.1 Write down the:

1.1.1 Letter that represents a ketone (1)

1.1.2 Structural formula of the functional group of compound **C** (1)

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

1.1.4 IUPAC name of compound **A** (3)

1.1.5 IUPAC name of compound **B** (2)

1.2 Compound **D** is a gas used in cigarette lighters.

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

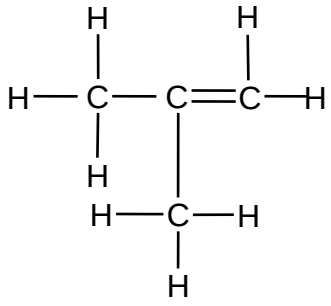
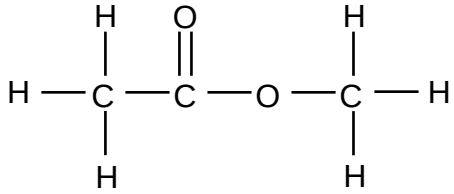
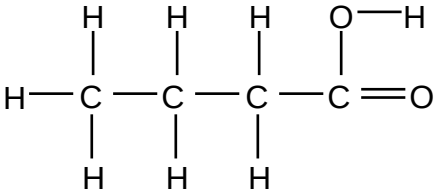
1.2.2 Write down the STRUCTURAL FORMULA and IUPAC NAME of a structural isomer of compound **D**. (4)

1.2.3 Is the isomer in QUESTION 1.2.2 a CHAIN, POSITIONAL or FUNCTIONAL isomer? (1)

[14]

QUESTION 2

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

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

2.1 Write down the LETTER that represents the following:

2.1.1 A hydrocarbon (1)

2.1.2 A functional isomer of compound **F** (1)

2.1.3 A compound which belongs to the same homologous series as compound **B** (1)

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

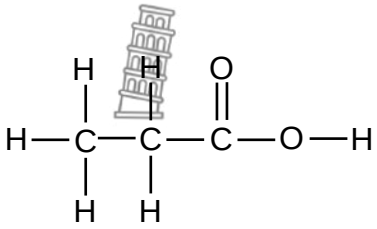
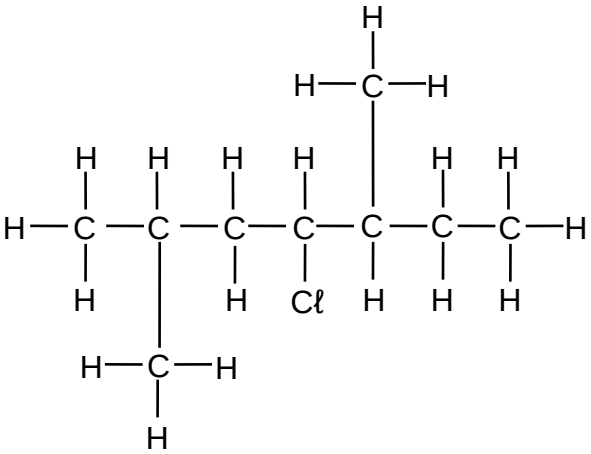
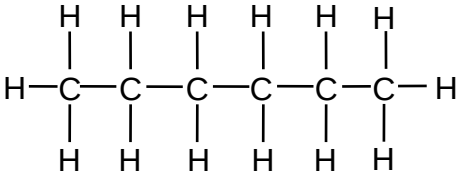
2.2.1 Compound **C** (3)

2.2.2 The acid used to prepare compound **B** (2)

[8]

QUESTION 3

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**	

3.1 Write down the LETTER that represents a compound that:

3.1.1 Is a haloalkane (1)

3.1.2 Has a hydroxyl group as functional group (1)

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

3.2 Write down the:

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

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

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

[9]

2. PHYSICAL PROPERTIES

Boiling point - is the temperature of a liquid at which its saturated vapour pressure equals the external atmospheric pressure.

Vapour pressure- The pressure exerted by a vapour at equilibrium with its liquid in a closed system.

Physical properties and intermolecular forces (IMF)

The strength of the IMF explains the physical properties of organic compounds.

Boiling point and melting point

The stronger the IMF, the more energy is needed to break the IMF. Thus a higher boiling point or melting point.

Vapour pressure

Weaker intermolecular forces allow substances (solids and liquids) to easily change to a vapour, thus increasing the vapour pressure.
When the IMF are strong, the vapour pressure will be low.

Factors that influence the strength of IMF

1. Surface area

Length of the carbon chain and **branched molecules**.

For compounds with the same functional group the larger the chains/larger the surface area, the IMF are stronger. The boiling point and melting point will thus be higher. The vapour pressure will decrease.

When a compound is more branched the molecules are the more compact or having less surface area then the IMF will be weaker.
This results in lower boiling points and melting points. The vapour pressure will increase.

2. The type of functional group

For compounds with comparable molecular mass (C-chain length) the functional group will be the determining factor regarding the strength of the IMF.
The strength of IMF is in the following order.

Carboxylic acid > Alcohol > Ketone & Aldehyde >Ester

Homologous series	Strength of IMF
Carboxylic acid	Two sites for H-bonding; stronger IMF
Alcohol	One site for H-bonding; Strong IMF but weaker than carboxylic acids
Ketone & Aldehyde	No Dipole-dipole forces weaker than H- bonding.
Ester	Dipole-dipole forces but weaker than that in ketone & Aldehyde
Alkane	Weak London forces

SOLVED PROBLEMS

QUESTION 1

The table below shows data collected for three organic compounds, represented by the letters **A**, **B** and **C**, during a practical investigation:

	Organic compound	**Relative molecular mass**	**Boiling point (°C)**
A	$CH_3CH_2CH_2CH_3$	58	-0,5
B	$CH_3CH_2CH_2OH$	60	97
C	CH_3COOH	60	118

1.1 Which variable was controlled during this investigation? (1)

1.2 Name the following in this investigation:

1.2.1 The dependent variable (1)

1.2.1 The independent variable (1)

1.3 Consider compound **A**:

1.3.1 Is compound **A**, a saturated or an unsaturated hydrocarbon? Give a reason for your answer. (2)

1.3.2 The compound 2-methylpropane is an isomer of compound **A**.

Predict whether the boiling point of 2-methylpropane will be HIGHER THAN, LOWER THAN or THE SAME as the boiling point of compound A. (1)

1.3.3 Explain your prediction in QUESTION 1.3.2. (3)

1.4 Refer to intermolecular forces and energy to explain why compound **B** will have a higher vapour pressure than compound **C** at 20 °C. (3) **[12]**

Solution

1.1 Controlled variable is a quantity that is kept constant in an investigation. If you look here the organic compounds are different. The only quantity that is almost constant is relative molecular mass/molar mass.

Relative molecular mass/molar mass ✓ (1)

1.2

1.2.1 To answer the next two questions we need to understand the investigation. The investigation is to find the boiling point of different types of organic compounds. Hence the boiling point depends on the type of organic compounds. So boiling point is the dependent and type of organic compound is the independent.

Boiling point ✓ (1)

1.2.2 Type of organic compound/homologous series/functional group ✓ (1)

1.3

1.3.1 Compound A is an alkane (C_4H_{10}). Alkane is saturated.

Saturated✓– single bonds only between C-atoms ✓ (2)

1.3.2 2-methylpropane is more branched and hence has less IMF. So boiling point is less than that of compound A which is butane.

LOWER THAN/*LAER AS* ✓ (1)

1.3.3 This is 3 mark question you need to write 3 sentences.

- First you **identify** the difference between the two compounds.
- Then **compare** the IMF between the two compounds.
- State which compounds need more **energy** to overcome the IMF.

(Remember the shortform **ICE**)

- 2-methylpropane is branched and has smaller surface area ✓
- It has less intermolecular forces✓
- Less energy required to overcome the intermolecular forces✓ (3)

1.4 Here compound B is an alcohol and C is an acid. Do **ICE** here also.
Identify – Both compounds have Hydrogen bond. But in alcohol there is only one site and in carboxylic acid there are 2 sites of hydrogen bonds.✓
Compare- The intermolecular force in alcohol is less than that of carboxylic caid.✓
Energy- Less energy is needed in alcohol to overcome intermolecular forces and hence it has high vapour pressure than carboxylic acid.✓ (3)

[12]

QUESTION 2

Compounds **A** to **E**, shown in the table below, are used during two investigations to determine factors which influence boiling point. The compounds are of similar molecular mass and therefore it is considered as a controlled variable.

Investigation	Compound		Relative molecular mass	Boiling point (°C)
I	**A**	2-methylbutane	72	27
	B	2,2-dimethylpropane	72	9
	C	Pentane	72	36
II	**D**	$CH_3CH_2CH_2CH_2OH$	74	117
	E	$CH_3CH_2CH_2CHO$	72	75

2.1 Compounds **A**, **B** and **C** are structural isomers. Write down the:

2.1.1 Name of the homologous series to which they belong (1)

2.1.1 Type of structural isomerism shown by these compounds (1)

2.2 Consider the boiling points of the compounds in investigation **I**.

2.2.1 Write down the independent variable for this investigation. (1)

2.2.2 Fully explain why boiling point increases from compound **A** to compound **C**. (3)

2.2.3 Which ONE of compounds **B** or **C** will have the higher vapour pressure at a given temperature? Refer to the data in the table to give a reason for the answer. (2)

2.3 Write down the type of intermolecular forces (Van der Waals forces) between molecules of each of the following compounds:

2.3.1 Compound **C** (1)

2.3.1 Compound **D** (2)

2.4 Consider investigation II. Refer to the type of Van der Waals forces in each of the compounds to give a reason why the boiling point of compound D is higher than that of compound E. (2)

[13]

Solution

2.1

2.1.1 Alkanes✓ / Alkane (1)

2.1.2 They are alkanes with 5 carbons but have different chains.

Chain (isomerism) ✓ (1)

2.2

2.2.1 It is clear that the dependent variable is boiling point. But it is changing or depending on what? It is depending on branching.

Branching✓ (1)

2.2.2

Identify

Chain length increases from compound A to C.✓

Compare

Intermolecular forces increases from compound A to C.✓

Energy/Energie

Energy needed to overcome intermolecular forces increases from compound A to C.✓ (3)

2.2.3 B✓

Lowest boiling point ✓ (2)

2.3.1 London forces ✓ (1)

2.2.2 London forces ✓

Hydrogen bond✓ (2)

2.4 Only 2 marks

Identify -Compound D has hydrogen bond and compound E has dipole-dipole forces.✓

Compare – IMF in compound D is stronger than that of compound E.✓ (2)

[13]

EXERCISES

QUESTION 1

Four compounds of comparable molecular mass are used to investigate the effect of functional groups on vapour pressure. The results obtained are shown in the table below.

COMPOUND		VAPOUR PRESSURE (kPa at 20 °C)
A	Butane	204
B	Propan-2-one	24,6
C	Propan-1-ol	2
D	Ethanoic acid	1,6

1.1 Define the term *functional group* of an organic compound. (2)

1.2 Which ONE of the compounds (**A**, **B**, **C** or **D**) in the table has the:

1.2.1 Highest boiling point
(Refer to the vapour pressures in the table to give a reason for the answer.) (2)

1.2.2 Weakest intermolecular forces (1)

1.3 Refer to the type of intermolecular forces to explain the difference between the vapour pressure of compound **A** and compound **B**. (3)

1.4 The vapour pressures of compounds **C** and **D** are much lower than those of compounds **A** and **B**. Name the type of intermolecular force in **A** and **B** that is responsible for this difference. (1)

1.5 Briefly explain the difference in vapour pressure between compound **C** and compound **D**. (2)
[11]

QUESTION 2

The table below shows five organic compounds represented by the letters **A** to **E**.

A	CH_4
B	CH_3CH_3
C	$CH_3CH_2CH_3$
D	$CH_3CH_2CH_2CH_3$
E	CH_3CH_2OH

2.1 Is compound **B** SATURATED or UNSATURATED? Give a reason for the answer. (2)

Consider the boiling points of compounds **A** to **E** given in random order below and use them, where applicable, to answer the questions that follow.

0 °C	- 162 °C	- 42 °C	- 89 °C	78 °C

2.2 Write down the boiling point of:

2.2.1 Compound **C** (1)

2.2.2 Compound **E** (1)

2.3 Explain the difference in boiling points of compounds **C** and **E** by referring to the TYPE of intermolecular forces present in EACH of these compounds. (3)

2.4 Does vapour pressure INCREASE or DECREASE from compounds **A** to **D**? Fully explain the answer. (4)

2.5 How will the vapour pressure of 2-methylpropane compare to the vapour pressure of compound **D**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

[12]

QUESTION 3

Learners investigate factors which influence the boiling points of alcohols.

They use equal volumes of each of the alcohols and heat them separately in a water bath. The temperature at which each boils is measured. The results obtained are shown in the table below.

ALCOHOLS	BOILING POINTS OF ALCOHOLS (°C)
Butan-1-ol	117,7
Pentan-1-ol	138,5
Hexan-1-ol	157,0

3.1 Define the term *boiling point*. (2)

3.2 What property of alcohols requires them to be heated in a water bath? (1)

3.3 Fully explain the trend in the boiling points. (3)

3.4 How will the boiling point of hexan-1-ol be affected if the volume of hexan-1-ol used is doubled? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

3.5 In another investigation the learners compare the boiling points of hexan-1-ol and hexanal.

3.5.1 Write down the independent variable for this comparison. (1)

3.5.2 They find that the boiling point of hexan-1-ol is higher than that of hexanal.

Fully explain this observation. (4)

[12]

3. ORGANIC REACTION

OXIDATION OF ALKANES (COMBUSTION)

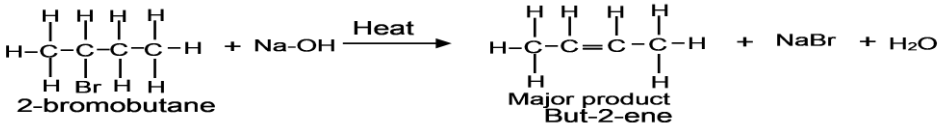
Alkane + oxygen ⟶ carbon dioxide + water + **energy**

Eg. $2C_6H_{14} + 19O_2 \longrightarrow 12CO_2 + 14H_2O \quad \Delta H < 0$

- This reaction is **exothermic** thus alkanes are used as fuel.

ADDITION , ELIMINATION and **SUBSTITUTION** reactions

- ***Addition*** reaction occurs when two or more reactants combine to form a single product.
  (*Unsaturated* compound → *Saturated* compound)
- ***Elimination* reaction** occurs when a reactant is broken up into two products.
  (*Saturated* compound → *Unsaturated* compound)
- ***Substitution*** reaction occurs when an exchange of atoms/groups of atoms in the reactants takes place.
  (*Saturated* compound → S*aturated* compound)



Conditions: **concentrated** strong base (NaOH, KOH, LiOH) + heat

Type of elimination: ***Dehydrohalogenation***

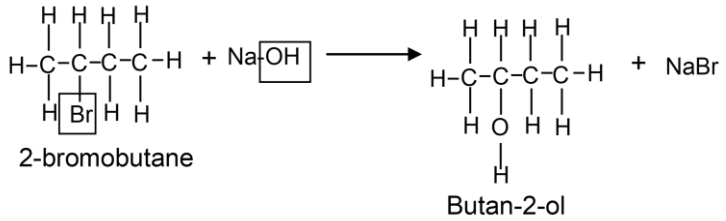
Reactants: Haloalkane + concentrated strong base **Products:** Alkene + NaBr + H_2O

Major product: The one where the **H atom** is removed from the C atom with the **least** number of H atoms.

ELIMINATION
Haloalkane →

REACTIONS OF HALOALKANES

SUBSTITUTION
Haloalkane → alcohol

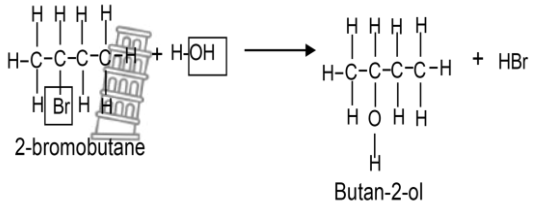


Conditions: **Dilute** strong base (NaOH/KOH/LiOH) + mild heat

Type of substitution: Hydrolysis

Reactants: Haloalkane + dilute strong base

Products: Alcohol + NaBr/KBr/LiBr



Conditions: Excess H_2O + mild heat

Type of substitution: ***Hydrolysis***

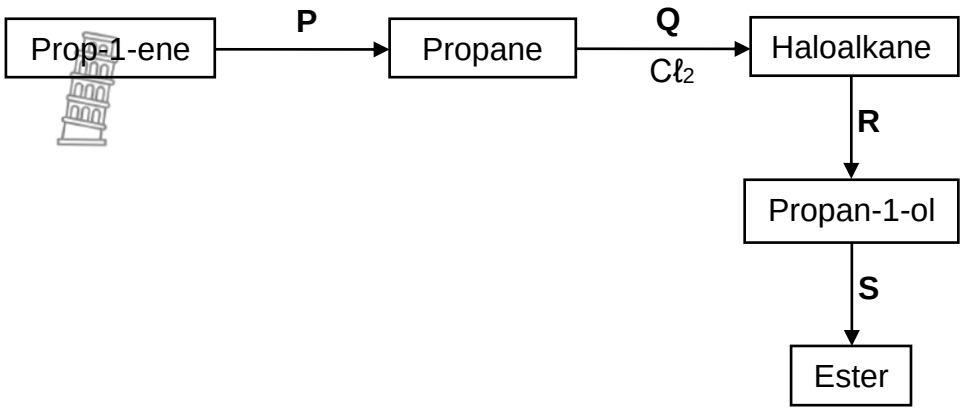
Reactants: Haloalkane + H_2O

Products: Alcohol + HBr

WORKED EXAMPLE

QUESTION 1

The flow diagram below shows the preparation of an ester using prop-1-ene as a starting reagent. **P**, **Q**, **R** and **S** represent different organic reactions.



1.1 Write down the type of reaction represented by:

1.1.1 **Q** (1)

1.1.2 **R** (1)

1.2 For reaction **P** write down the:

1.2.1 Type of addition reaction (1)

1.2.2 Balanced equation using structural formulae (3)

1.3 Write down the structural formula of the haloalkane formed in reaction **Q**. (2)

1.4 In reaction **S** propan-1-ol reacts with ethanoic acid to form the ester.

For this reaction write down the:

1.4.1 Name of the reaction that takes place (1)

1.4.2 FORMULA or NAME of the catalyst needed (1)

1.4.3 Structural formula of the ester formed (2)

1.4.4 IUPAC name of the ester formed (2)

1.5 The propan-1-ol formed in reaction **R** can be converted to prop-1-ene. Write down the FORMULA or NAME of the inorganic reagent needed. (1)

[15]

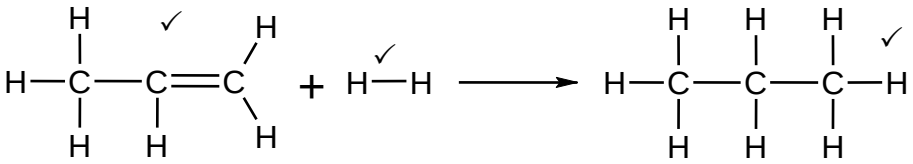
Solution

1.1.1 Here alkane changes to haloalkane by reacting with chlorine which is a halogen.
saturated → saturated.
Substitution / chlorination / halogenation ✓ (1)

1.1.2 saturated → saturated.
Substitution (1)

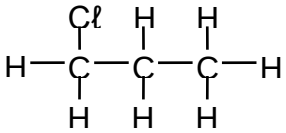
1.2.1 Hydrogen is added.
Hydrogenation ✓ (1)

1.2.2



(3)

1.3 One hydrogen is substituted with a chlorine

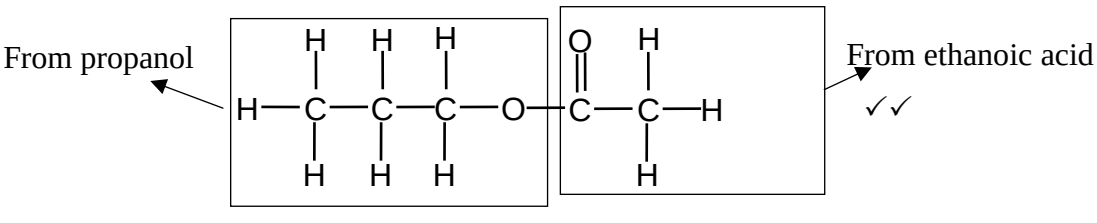


(2)

1.4
1.4.1 Esterification / Condensation ✓ (1)

1.4.2 (Concentrated) H_2SO_4 / (Concentrated) sulphuric acid ✓ (1)

1.4.3



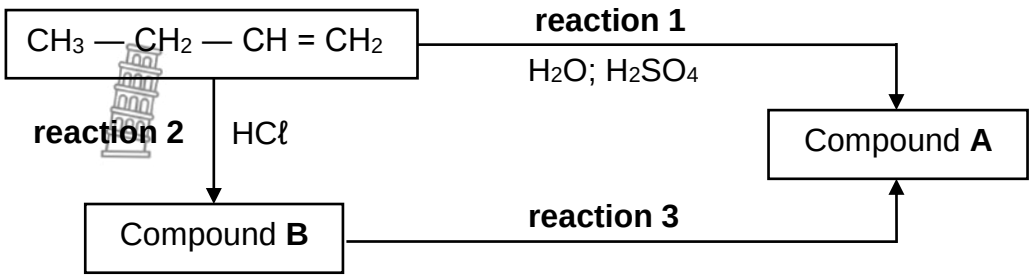
(2)

1.4.4 Propyl ✓ ethanoate ✓ (2)

1.5 Sulphuric acid / H_2SO_4 / Phosphoric acid / H_3PO_4 ✓ (1)
[15]

QUESTION 2

In the flow diagram below, but-1-ene is used as starting material in the preparation of compound **A**.



2.1 Is but-1-ene a SATURATED or UNSATURATED compound? Give a reason for the answer. (2)

2.2 Compound **A** is the major product formed in **reaction 1**.

Write down the:

2.2.1 Structural formula of compound **A** (2)

2.2.2 Type of reaction that takes place (1)

2.3 For compound **B**, write down the:

2.3.1 IUPAC name (2)

2.3.2 Structural formula of the positional isomer (2)

2.4 For **reaction 3**, write down:

2.4.1 TWO reaction conditions needed (2)

2.4.2 The type of reaction that occurs (1)

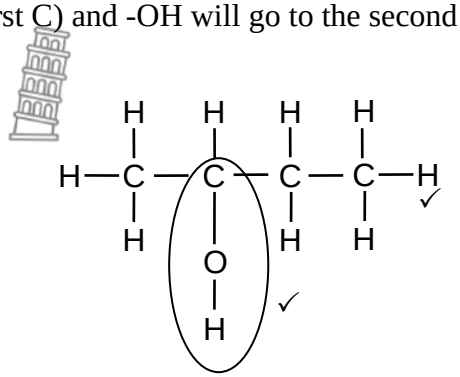
2.4.3 A balanced equation, using molecular formulae (3)

[15]

Solution

2.1 But-1-ene is an alkene and is unsaturated.
Unsaturated ✓
Contains a double bond/multiple bond (between C atoms). ✓ (2)

2.2.1 But-1-ene reacts with water (H-OH). H will go to the carbon having highest number of H s (first C) and -OH will go to the second carbon.



(2)

2.2.2 unsaturated → saturated is addition

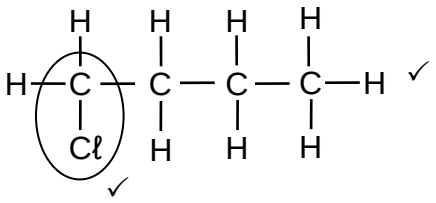
(1)

Addition/hydration ✓

2.3 But-1-ene reacts with H-Cℓ. H will go to the carbon having highest number of H s (first
2.3.1 C) and Cℓ will go to the second carbon.

2-chlorobutane ✓✓ (2)

2.3.2 Positional isomer means -Cℓ should be attached to another carbon other than second carbon. So it can connect to first carbon.



(2)

2.4 Reaction 3 is Haloalkane → Alcohol

2.4.1

- H_2O OR dilute NaOH/KOH ✓
- Mild heat ✓ (2)

2.4.2 Reaction 3 is Haloalkane → Alcohol
saturated → saturated

Substitution/hydrolysis ✓ (1)

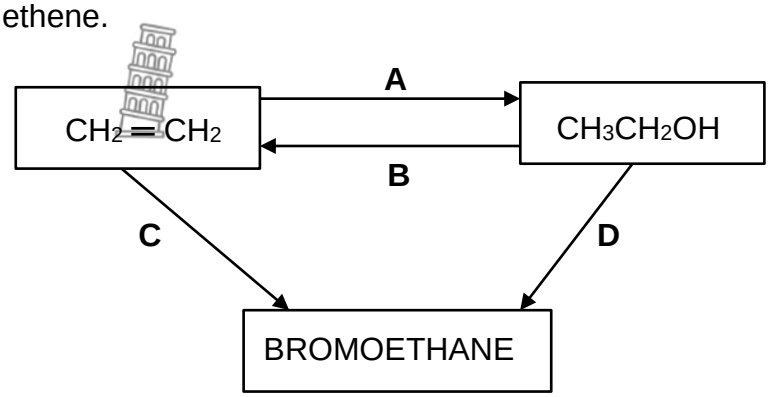
2.4.3 Chlorobutane + NaOH → butanol + Sodium chloride

$C_4H_9C\ell$ + NaOH ✓ → $C_4H_{10}O$ + $NaC\ell$ ✓ bal. ✓ (3)
[15]

EXERCISES

QUESTION 1

The letters **A-D** in the flow diagram below represent some organic reactions that involve ethene.



1.1 Name the type of reaction (ADDITION, SUBSTITUTION or ELIMINATION) represented by:

1.1.1 **A** (1)

1.1.2 **B** (1)

1.1.3 **C** (1)

1.2 Apart from the alkene, another reactant and a catalyst are needed in Reaction **A**.

Write down the NAME of the:

1.2.1 Other reactant (1)

1.2.2 Catalyst which was added to the alkene (1)

1.3 Use STRUCTURAL FORMULAE to write down a balanced chemical equation for the reaction represented by **C**. (4)

1.4 The ethanol produced in reaction **A** is made to react with a carboxylic acid in the presence of an acid catalyst. The compound formed is a STRAIGHT CHAIN ESTER which is a functional isomer of pentanoic acid.

Write down the :

1.4.1 IUPAC NAME of the carboxylic acid that reacted with the alcohol (2)

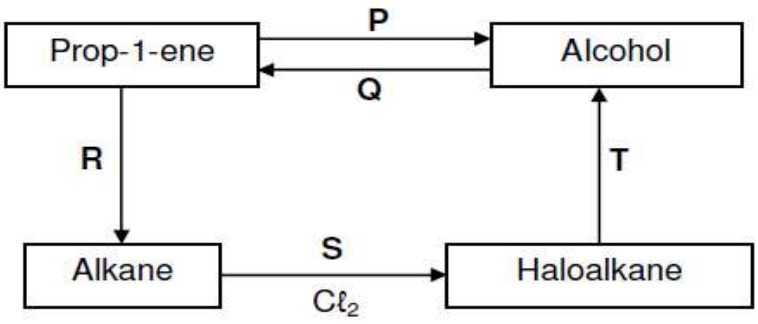
1.4.2 Name given to this type of reaction (1)

1.4.3 STRUCTURAL FORMULA of the ester formed (2)

[14]

QUESTION 2

In the flow diagram below prop-1-ene is used as starting reagent in the preparation of other compounds. **P** to **T** represent chemical reactions.



2.1 Name the type of reaction represented by:

2.1.1 **P** (1)

2.1.2 **S** (1)

2.1.3 **Q** (1)

2.2 Consider reaction **P**. Write down the:

2.2.1 FORMULA of a suitable catalyst (1)

2.2.2 Structural formula of the alcohol (2)

2.3 For reaction **R**, write down:

2.3.1 The type of addition reaction (1)

2.3.2 A balanced equation using structural formulae (3)

2.4 During reaction **T**, the haloalkane reacts with a base to form the alcohol in QUESTION 2.2.2. Write down the:

2.4.1 IUPAC name of the haloalkane (2)

2.1.2 NAME of a suitable base (1)

2.1.2 TWO reaction conditions for this reaction (2)

[15]

RATE AND EXTEND OF REACTIONS

For NSC there will be ±20 marks from this topic. Our target is minimum of 10 Marks

Heat of reaction- *Energy absorbed or released in a chemical reaction*.

Exothermic reaction- *Reactions that release energy.*

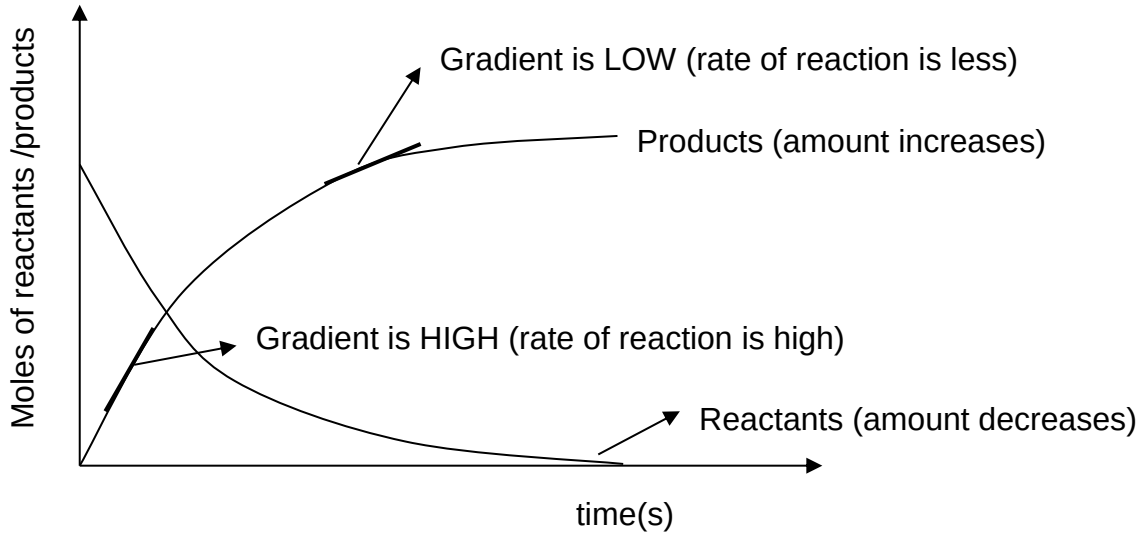
Endothermic reaction- *Reactions that absorb energy.*

Activation energy- *Minimum energy needed for a reaction to take place.*

Rate of reaction- *Change in concentration of reactants or products per unit time.*

Catalyst - A *substance that increases the rate of a chemical reaction*.

Graph of amount vs time



Factors affecting the rate of reactions

Surface area	Powder form – Increases the surface area. More effective collisions per unit time. Rate of reaction increases.
Concentration	Increasing concentration increases the number of particles. More effective collisions per unit time. Rate of reaction increases.
Temperature	Increasing temperature increases the speed of particles. More effective collisions per unit time. Rate of reaction increases.
Catalyst	Catalyst decreases the activation energy. More effective collisions per unit time. Rate of reaction increases.

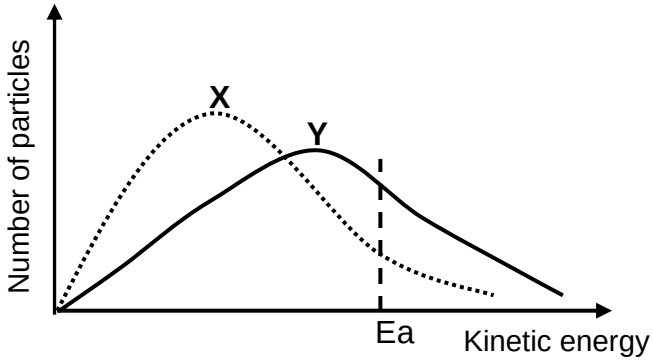
SOLVED PROBLEMS

QUESTION 1

A group of learners were investigating the factors affecting the rate of reaction of zinc in excess dilute hydrochloric acid according to the following balanced equation:

$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

The graph **X** below represents the initial reaction and graph **Y** represents the reaction when the learners changed one of the factors.



1.1 Identify the factor that was changed. (1)

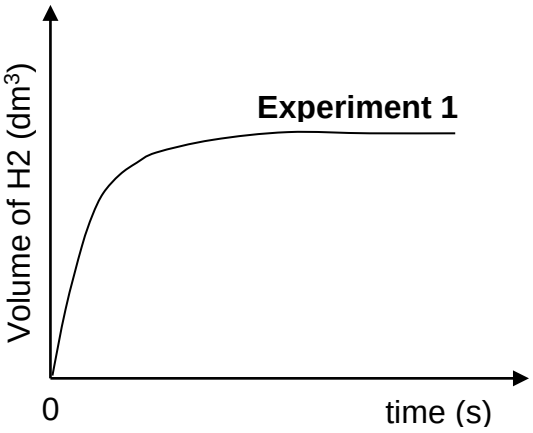
1.2 Which graph (**X** or **Y**) represent a higher reaction rate. (1)

1.3 Use collision theory to explain how the factor in QUESTION 1.1 affects the reaction rate. (2)

1.4 Learners repeated three sets of experiments at constant temperature but they varied some factors as described in the table below.

	MASS OF Zn (g)	**STATE OF Zn**	**CONCENTARTION OF HCℓ ($mol \cdot dm^{-3}$)**
Experiment 1	2	Powder	0,2
Experiment 2	3	Powder	0,2
Experiment 3	2	Granules	0,2

The graph given below shows the volume of $H_2(g)$ formed against time for **Experiment 1**.



1.4.1 Redraw the graph above in the answer book. On the same set of axes sketch the curve for **Experiment 3.** Label the curve **Experiment 3.** (2)

1.4.2 Calculate the volume of $H_2(g)$ formed in **Experiment 1**. Assume that $H_2(g)$ is formed at STP. (5)

1.4.3 How will the volume of $H_2(g)$ formed in **Experiment 2** compared to that in **Experiment 1.**

Choose from GREATER THAN, LESS THAN or EQUAL TO.

Explain your answer using collision theory. (3)

1.4.4 Calculate the average reaction rate (in $mol \cdot s^{-1}$) for **Experiment 2**, if the reaction has completed in 60 s. (3)
[17]

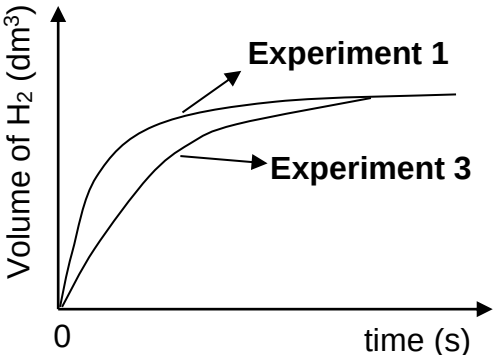
Solution

1.1 **X** represents the initial reaction and graph **Y** represents the reaction where the learners changed one of the factors.
What happened to the second graph(Y)?→ K.E increased.
When will KE increases?→ When the temperature increases.
So the answer is:
Temperature✓ (1)

1.2 We established that Y is the graph at higher temperature.
When temperature increases rate will also increase.
So the answer is:
Y✓ (1)

1.3 Increasing temperature increases the speed of particles.✓
More effective collisions per unit time.✓
(Rate of reaction increases). (2)

1.4.1 Experiment 3 uses granules (less surface area). So the rate of reaction will less. Hence the graph will have less gradient. But will form the same amount of H_2.



(2)

1.4.2 Here HCℓ is excess. So the amount of $H_2(g)$ formed depends on the amount of Zn.
First convert the mass of Zn to number of moles.

$$n_{Zn} = \frac{m}{M}$$

$$= \frac{2}{65} \checkmark$$

$$= 0{,}0308 \text{ mol}$$

The equation is
Ratio of Zn :H_2 = 1:1
$n_{H_2} = n_{H_2} = 0{,}0308$ mol✓
Now convert the number of moles to volume

$$n = \frac{V}{V_m} \checkmark$$

$$0{,}0308 = \frac{V}{22{,}4} \checkmark$$

$$= 0{,}6899 \text{ dm}^3 \checkmark$$ (5)

1.4.3 In Experiment 2 there is more mass of Zn used than in Experiment 1. So there will be more particles and more effective collisions per second which results in higher reaction rate.
Greater than✓
More particles. ✓
More effective collisions per second.✓ (3)

1.4.4 In Experiment 2 mass of Zinc is given. It has to convert to number of moles.

$$n_{Zn} = \frac{m}{M}$$

$$= \frac{3}{65}$$

$$= 0{,}0462 \text{ mol}$$

$$\text{Reaction rate} = \frac{\Delta n}{\Delta t} \quad (\Delta n = \text{change in number of moles} = n_i - n_f) \checkmark$$

$$= \frac{0{,}0462(-0)}{60(-0)} \checkmark$$

$$= 7{,}7 \times 10^{-4} \text{ (mol·s}^{-1}\text{)} \checkmark$$

(3)
[20]

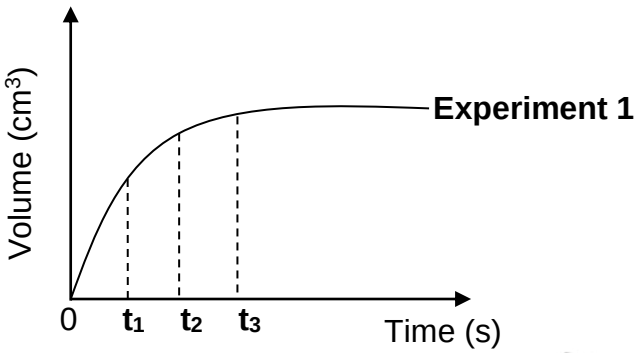
QUESTION 2

Dilute acids, indicated in the table below, react with EXCESS zinc in each of the three experiments to produce hydrogen gas. The zinc is completely covered with the acid in each experiment.

EXPERIMENT	DILUTE ACID
1	100 cm^3 of 0,1 mol·dm^{-3} H_2SO_4
2	50 cm^3 of 0,2 mol·dm^{-3} H_2SO_4
3	100 cm^3 of 0,1 mol·dm^{-3} HCℓ

The volume of hydrogen gas produced is measured in each experiment.

The graph below was obtained for **Experiment 1**.



Use this graph and answer the questions that follow.

2.1 At which time (t_1, t_2 or t_3) is the:

2.1.1 Reaction rate the highest (1)

2.1.2 Mass of zinc present in the flask the smallest (1)

2.2 In which time interval, **between t_1 and t_2** OR **between t_2 and t_3**, does the largest volume of hydrogen gas form per second? (1)

2.3 Redraw the graph for **Experiment 1** in the ANSWER BOOK.

On the same set of axes, sketch the graphs that will be obtained for **Experiments 2**. Clearly label the graphs as **EXPERIMENT 1** and **EXPERIMENT 2**. (2)

2.4 The initial mass of zinc used in each experiment is 0,8 g. The balanced equation for the reaction in **Experiment 3** is:

$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

Calculate the mass of zinc present in the flask after completion of the reaction in **Experiment 3**. (5) **[10]**

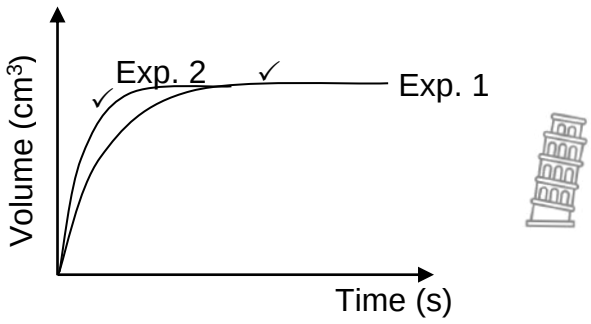
Solution

2.1.1 Reaction rate is highest when the gradient is highest which is at t_1.
t_1 ✓ (1)

2.1.2 When the reaction is progressing, the zinc is used up. So near to the end of the reaction the mass of Zn will be less. So from the given times t_3 is towards the end of reaction.
t_3 ✓ (1)

2.2.2 Question is asking when will the production of hydrogen gas be the largest. It will be the largest when the rate of reaction is highest (higher gradient). From the given times it is clear that the section from t_1 and t_2 has higher gradient.
Between t_1 and t_2 ✓ (1)

2.3 This is a very tricky question. Here in both experiments 1 and 2, the number of moles of acid reacting will be the same. (n = cV). So in both the volume of H_2 produced will be the same. But in experiment 2 the concentration is double than that of experiment. So the initial rate of experiment 2 will be high and the reaction will finish early.



(2)

2.4

In Experiment 3, the volume of acid is 100 cm^3 and the concentration is 0,1 $mol \cdot dm^{-3}$

We need to convert this into number of mols.

$n(HC\ell) = cV$

$= (0,1)(100 \times 10^{-3})$ ✓

$= 0,01$ mol

Now use the mole ratio in the reaction to find the amount of Zn reacted.

$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$

Zn : $HC\ell$ = 1: 2

That is for every 2 moles of $HC\ell$, 1 mole of Zn is used. Or the amount of Zn used is half of that of $HC\ell$.

n(Zn reacted):

$n(Zn) = \frac{1}{2}n(HC\ell)$

$= \frac{1}{2}(0,01)$ ✓

$= 5 \times 10^{-3}$ mol

The question is asking about the mass. So we need to convert mole to mass.

$m(Zn) = (5 \times 10^{-3})(65)$ ✓ = 0,325 g

Initially we had 0,8 g of Zn and out of which 0,325 g is reacted. So the amount left is:

$m(Zn_{left}) = 0,8 - 0,325$ ✓

= 0,48 g ✓ (0,475 g)

(5)
[10]

EXCERCISES

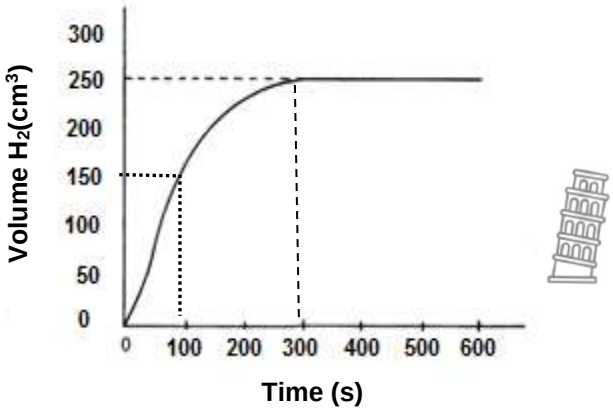
QUESTION 1

A group of learners conduct an experiment to investigate the rate of a reaction. The learners use a small amount of granulated zinc which is added to excess hydrochloric acid.

The balanced equation for the reaction is as follows:

$$Zn\ (s) + 2HC\ell\ (aq) \rightarrow ZnC\ell_2\ (aq) + H_2\ (g)$$

The hydrogen gas produced is collected at 290K. By measuring the volume of gas produced as a function of time, the graph below was obtained.



1.1 What information does the gradient of this graph give? (2)

1.2 Describe how the gradient of this graph changes between t = 100s and t = 200 s? Give a reason for your answer. (2)

1.3 Give a reason why the graph becomes flat after 300 seconds? (2)

1.4 Calculate the average rate of reaction in $cm^3 \cdot s^{-1}$ for the first 100s. (3)

1.5 Use the collision theory to explain how the rate of the above reaction will change when the temperature is increased from 290K to 313K. (3)

1.6 The gas liberated in this experiment was collected at STP. Calculate the mass of zinc that was used. (5)

[17]

QUESTION 2

The reaction of zinc and EXCESS dilute hydrochloric acid is used to investigate factors that affect reaction rate. The balanced equation for the reaction is:

$$Zn(s) + 2HC\ell(aq) \longrightarrow ZnC\ell_2(aq) + H_2(g)$$

The reaction conditions used and the results obtained for each experiment are summarised in the table below.

The same mass of zinc is used in all the experiments. The zinc is completely covered in all reactions. The reaction time is the time it takes the reaction to be completed.

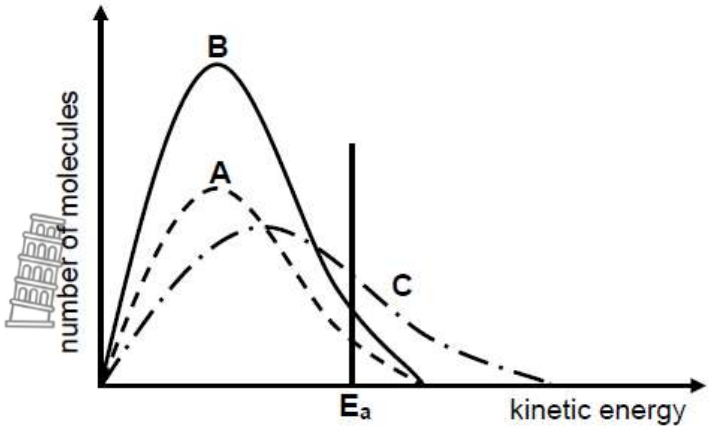
EXPERIMENT	CONCENTRATION OF HCℓ ($mol \cdot dm^{-3}$)	VOLUME OF HCℓ (cm^3)	STATE OF DIVISION OF Zn	TEMPERATURE OF HCℓ (°C)	REACTION TIME (min.)
1	2,0	200	powder	25	7
2	1,5	200	granules	25	14
3	5,0	200	powder	25	5
4	1,5	400	granules	25	x
5	2,0	200	powder	35	4

2.1 Experiment **1** and experiment **5** are compared. Write down the independent variable. (1)

2.2 Define *reaction rate*. (2)

2.3 Write down the value of **x** in experiment **4**. (2)

2.4 The Maxwell-Boltzmann energy distribution curves for particles in each of experiments **1**, **3** and **5** are shown below.



Identify the graph (**A** or **B** or **C**) that represents the following:

2.4.1 Experiment 3
Give a reason for the answer. (2)

2.4.2 Experiment 5
Give a reason for the answer. (2)

2.5 Experiment **6** is now conducted using a catalyst and the SAME reaction conditions as for Experiment **1**.

2.5.1 What is the function of the catalyst in this experiment? (1)

2.5.2 How will the heat of reaction in experiment **6** compare to that in experiment **1**? Choose from: GREATER THAN, EQUAL TO or LESS THAN. (1)

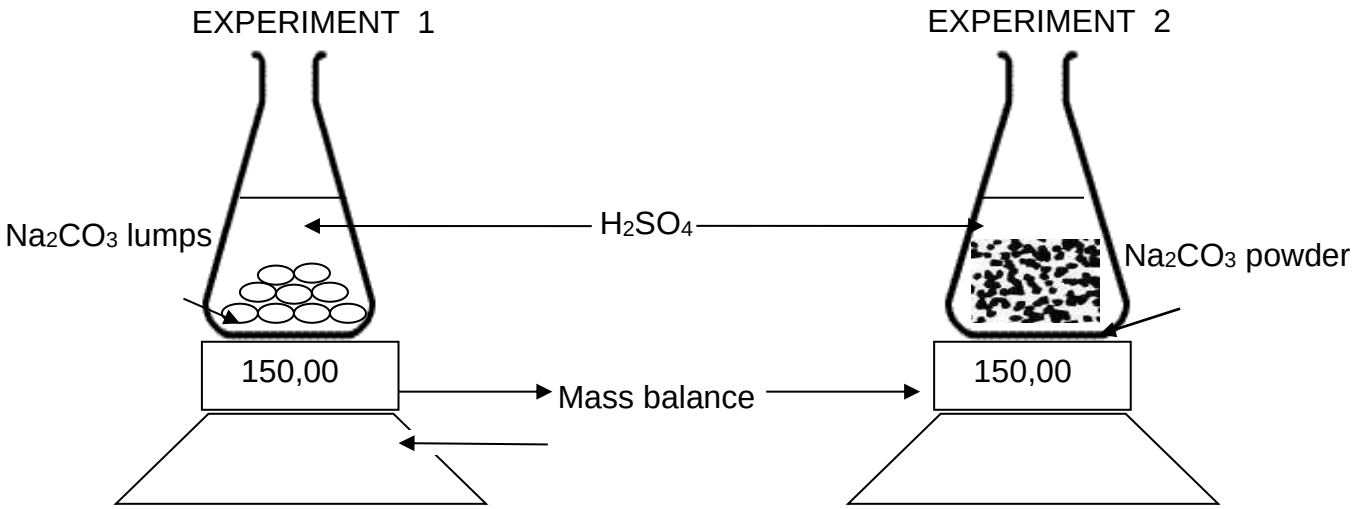
2.6 Calculate the average rate of the reaction (in $mol \cdot min^{-1}$) with respect to zinc for experiment **2** if 1,5 g of zinc is used. (4)
[15]

QUESTION 3

The reaction between sodium carbonate (Na_2CO_3) and sulphuric acid (H_2SO_4) was used to investigate one of the factors affecting reaction rate. The balanced equation is given below.

$$Na_2CO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + CO_2(g) + H_2O(\ell)$$

Two experiment are conducted as illustrated below.



In both experiments the same amount of sodium carbonate is added to an excess of sulphuric acid solution in a conical flask placed on a mass balance. The mass of the flask together with its contents is recorded every 15 s.

3.1 Define the term *reaction rate*. (2)

3.2 For the investigation described above, write down:

3.2.1 The independent variable (1)

3.2.2 ONE controlled variable (1)

The results obtained in EXPERIMENT 1 are shown in the table below.

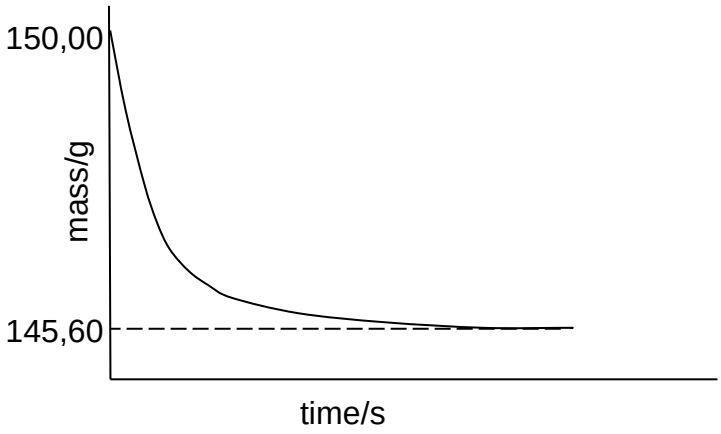
Time (s)	0	15	30	45	60	75	90	105	120
Mass (g)	150,00	147,50	146,60	146,00	145,80	145,70	145,60	145,60	145,60

3.3 Write down the NAME or FORMULA of the substance responsible for the decrease in mass. (1)

3.4 How long does it take for the reaction in EXPERIMENT 1 to be completed? (1)

3.5 How will the rate of the reaction in EXPERIMENT 2 compare to that in EXPERIMENT 1? Write down GREATER THAN, SMALLER THAN or EQUAL TO. Briefly explain your answer by referring to the collision theory. (3)

3.6 The sketch graph below **(not drawn to scale)** represents the results obtained for EXPERIMENT 1.



3.6.1 Use the information in the graph to determine the mass of sodium carbonate that has reacted in EXPERIMENT 1. (5)

3.6.2 Redraw the above sketch graph in your ANSWER BOOK. On the same set of axes, sketch the curve obtained for EXPERIMENT 2. **Label your graph as Exp.2**. (2)

[16]

CHEMICAL EQUILIBRIUM

For NSC there will be ±20 marks from this topic. Our target is just 5 Marks

Reversible reaction- is a reaction when products can be converted back to reactants.

Chemical equilibrium - Dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.

Le Chatelier's principle: When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance.

Equilibrium constant (Kc)

Ex.1 $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$

$$K_C = \frac{[HI]^2}{[H_2][I_2]}$$

Ex.2 $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

We do not put solid and liquid phases in the Kc expression. Keep the concentrations of solid phase reagents as 1. But DO NOT INCLUDE them in the Kc expressions.

So here C is in solid phase. So we do not include C in the Kc expression.

$$K_C = \frac{[CO]^2}{[CO_2]}$$

Ex.3 $P_4(s) + 5O_2(g) \rightleftharpoons P_2O_{10}(s)$

P_4 and P_2O_{10} are in solid phase. So we will not include them in the Kc expression.

$$K_C = \frac{1}{[O_2]^5}$$

EXERCISES

1. Write down the Kc expressions for the following reactions.

   1.1 $2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g)$

   1.2 $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

   1.3 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

   1.4 $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$

   1.5 $Br_2(\ell) + 2O_3(g) \rightleftharpoons O_2(g) + 2BrO_2(s)$

ACIDS AND BASES

For NSC there will be ±20 marks from this. But we are targeting only 5 Marks mostly for definitions.

Arrhenius theory

Acids- produce **hydrogen ions** in aqueous solution.

Bases- produce **hydroxide ions** in aqueous solution.

Lowry-Brønsted theory

Acid -is a proton **donor**.

Base is a proton **acceptor**.

Strong acids - ionise **completely** in water to form a high concentration of H_3O^+ ions.

Weak acids - ionise **incompletely** in water to form a low concentration of H_3O^+ ions.

Strong bases - dissociate **completely** in water to form a high concentration of OH^- ions.

Weak bases -dissociate **incompletely** in water to form a low concentration of OH^- ions.

Hydrolysis - is the reaction of a salt with water.

ELECTROCHEMICAL REACTIONS

For NSC there will be ±30 marks from this topic. We are targeting at least 10 Marks.

Oxidation (in terms of electron (e-) transfer)	A loss of electrons.
Reduction	A gain of electrons.
Oxidation: (In terms of oxidation numbers)	An increase in oxidation number
Reduction	A decrease in oxidation number
Oxidising agent	A substance that is reduced/gains electrons.
Reducing agent	A substance that is oxidised/loses electrons.
Anode	The electrode where oxidation takes place
Cathode	The electrode where reduction takes place
Electrolyte	A solution/liquid/dissolved substance that conducts electricity through the movement of ions
Electrolysis	The chemical process in which electrical energy is converted to chemical energy OR the use of electrical energy to produce a chemical change.

GALVANIC CELLS

Galvanic cell	A cell in which chemical energy is converted into electrical energy. A galvanic (voltaic) cell has self-sustaining electrode reactions

➢ **HOW TO IDENTIFY A GALVANIC CELL:**

- It will contain a *Voltmeter* or *Light bulb* (chemical energy to electrical energy)

> Functions of the salt bridge

The salt bridge:

- separates the electrolytes so that they do not mix.
- completes the circuit.
- supplies a path through which ions can move to restore neutrality.

The emf or cell potential:

$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$

or/*of*

$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$

or/*of*

$E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$

Standard conditions:

1. The temperature at which the cell operates is 25°C.
2. The concentration of the electrolyte is 1 mol·dm-3.
3. The pressure is 1 atmospheric pressure / 101 kPa
   (ONLY applicable to half-cells where gas is used)

REMEMBER!!

If E_{cell} value is **positive ($E^{o}cell$ >0)** then

1. the reaction is **spontaneous**
2. the reaction is **exothermic**

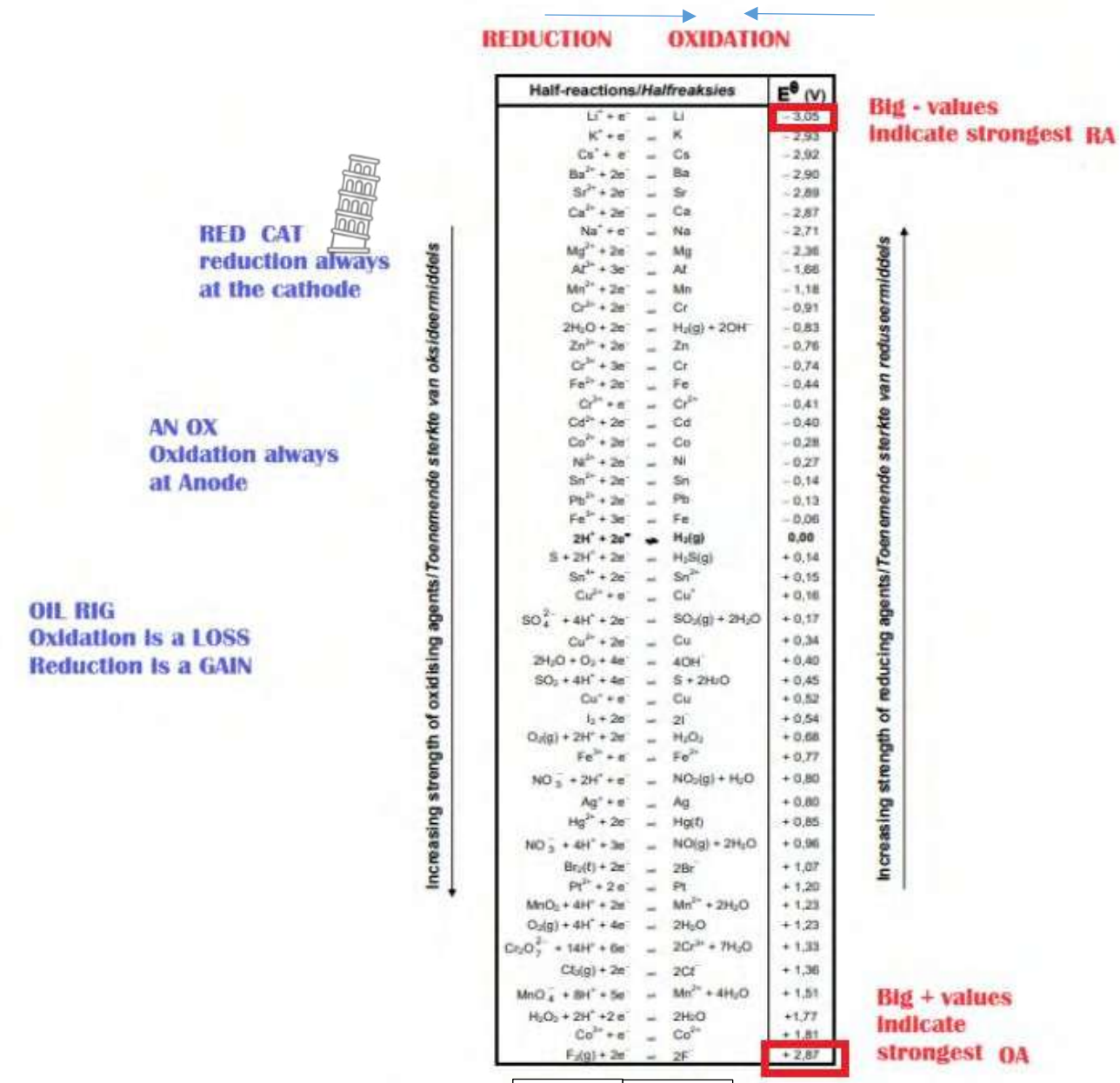
Cell notation

reducing agent | oxidised species || oxidising agent | reduced species

Example: In Zn- Cu cell the cell notation can be written as:

$Zn(s) \mid Zn^{2+}(aq)$ (1 mol.dm^{-3}) || $Cu^{2+}(aq)$ (1 mol.dm $^{-3}$) | Cu(s)

2: KNOW HOW TO USE YOUR REDOX TABLE



RED | OX

REDOX reactions that take place simultaneously

REDUCTION

- Reactant *GAIN electrons*
- This reactant will be the *Oxidising Agent*.
- *Oxidation no* of this reactant will *decrease*…

$$Cu^{2+} + 2e^- \rightarrow Cu$$
(+2 → 0: decrease in ON)

- Will take place at the *Cathode*

OXIDATION

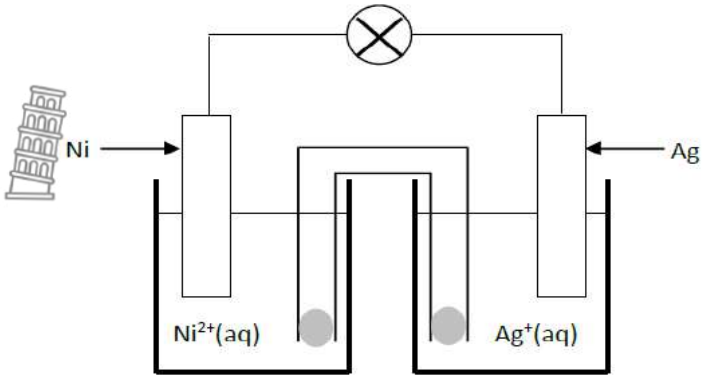
- Reactant *LOSES electrons*
- This reactant will be the *Reducing Agent*.
- *Oxidation no* of this reactant will *increase*…

$$Zn \rightarrow Zn^{2+} + 2e^-$$
(0 → +2: increase in ON)

- Will take place at the *Anode*

EXAMPLE 1

The diagram below represents an electrochemical cell under standard conditions. A suitable bulb in the external circuit glows brightly.



1.1 Which type of electrochemical cell is represented? Only write down ELECTROLYTIC or GALVANIC. (1)

1.2 Write down TWO standard conditions applicable to this cell. (2)

1.3 In which direction do electrons flow in the external circuit? Only write down 'from Ni to Ag' or 'from Ag to Ni'.

Refer to the relative strengths of reducing agents present to explain the answer. (3)

1.4 Write down the cell (symbolic) notation for this cell. (3)

1.5 Which electrode will experience an increase in mass while the cell is functioning? (1)

1.6 Calculate the initial emf of this cell. (4)
[14]

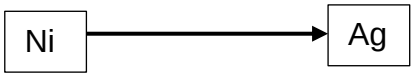
Solution

STEP 1: IDENTIFY THE TYPE OF CELL

- *HINT*: LIGHTBULB/ VOLTMETER- WILL SHOW THAT CHEMICAL ENERGY IS CONVERTED TO ELECTRICAL ENERGY. THEREFORE IT WILL BE AN_____

STEP 2: IDENTIFY THE METALS (REACTANTS). USE REDOX TABLE TO WRITE DOWN ALL THE NECCESARY INFORMATION

Ni^{2+} - 0,27 V	Ag^{1+} +0,80 V
• Negative Value- indicates that Nickel is the Reducing Agent (RA) • Oxidation will take place at the Nickel half cell • Ni will lose electrons • Ni is the *Anode* of the half cell	• Positive Value- indicates that Ag is the OA • Reduction will take place at the Ag half cell • Ag will gain electrons • This is the *Cathode* of the half cell



- Cell notation in this direction
- External electron flow in this direction

STEP 3: NOW TRY TO ATTEMP THE QUESTIONS!!!

1.1 Galvanic ✓ (1)

1.2 There are no gases. So we can only write the first two conditions.
galvanic / *galvanies* ✓ (2)

1.3 Ni to Ag ✓
Ni is a stronger reducing agent than Ag ✓
Ni will be oxised./ release electrons. ✓ (3)

1.4 The correct order of writing the cell notation is:
reducing agent | oxidised species || oxidising agent | reduced species

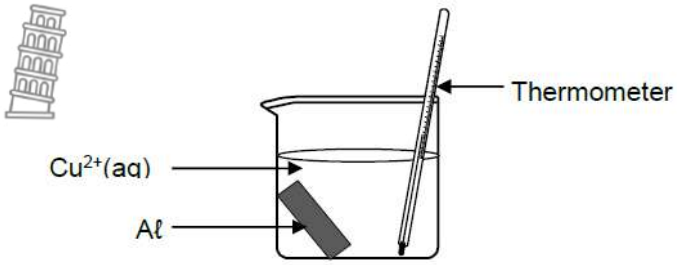
Ni | Ni^{2+} ✓ ‖ Ag^{+} | Ag ✓ (3)

1.5 The electrode that gains mass is the cathode. Here the cathode is silver.
Ag ✓ (1)

1.6 $E^{o}_{cell/sel} = E^{o}_{cathode/katode} - E_{anode}$ ✓
= 0,8 ✓ – (-0,27) ✓
= 1,07 V ✓ (4)
[14]

QUESTION 2

2.1 A strip of aluminium is placed in a beaker containing a blue solution of a copper (II) salt. After a while the solution becomes colourless.

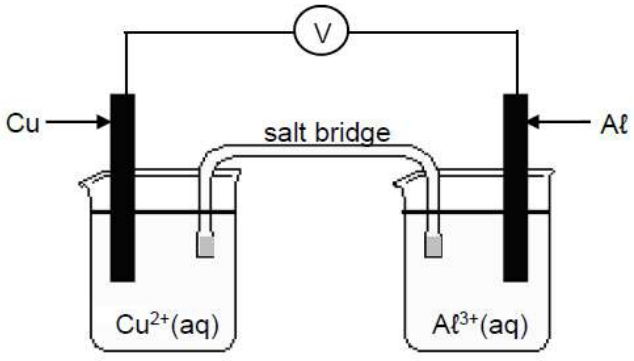


2.1.1 How would the reading on the thermometer change as the reaction proceeds? Write down INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

2.1.2 Refer to the reducing ability of aluminium to explain why the solution becomes colourless. (2)

2.1.3 Write down the balanced net IONIC equation for the reaction that takes place. (3)

2.2 The electrochemical cell shown below functions at standard conditions.



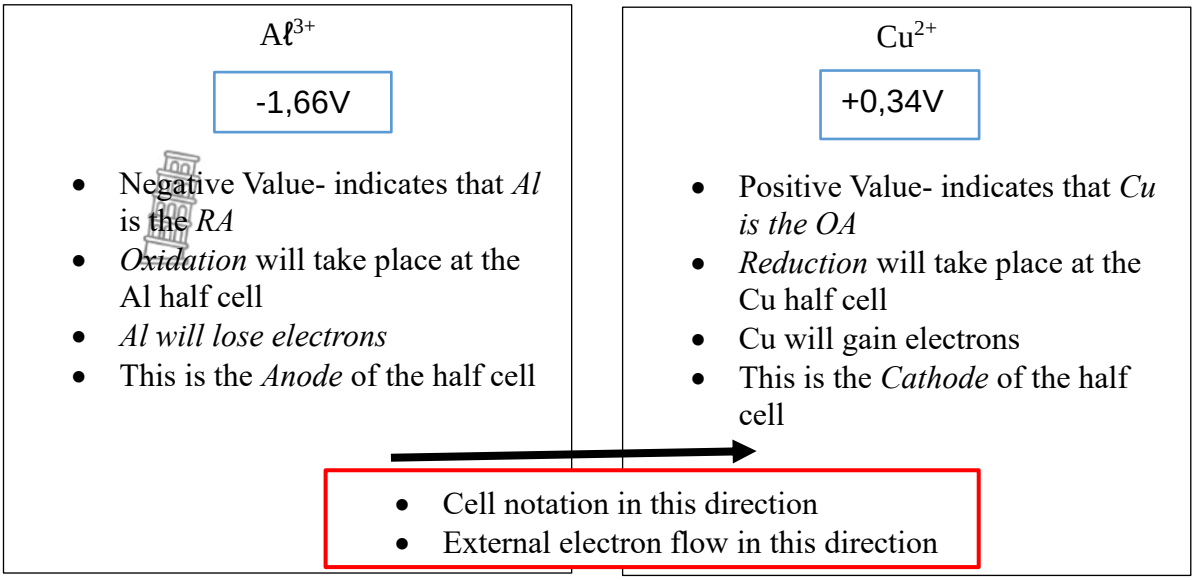
2.2.1 Which electrode (Cu or Aℓ) is the anode? (1)

2.2.2 Write down the cell notation for this cell. (3)

2.2.3 Calculate the emf of this cell. (4)

[15]

Solution



2.1.1 In galvanic cells the REDOX reaction is exothermic and heat is released.
Increases ✓
The reaction is exothermic.✓

2.1.2 The blue colour of the solution is due to the Cu^{2+} ions. Aluminium gives the electrons to Cu^{2+} and Cu^{2+} ions changes to copper. Hence the blue colour will fade.

Aluminium is a strong reducing agent/stronger reducing agent ✓ than copper and will reduce the copper(II) ions to copper. ✓

2.1.3 We need to write the reduction half reaction and oxidation half reaction first.

Oxidation half reaction: $A\ell \rightarrow A\ell^{3+} + 3e^-$
Reduction half reaction: $Cu^{2+} + 2e^- \rightarrow Cu$
The number of electrons in both reactions must be the same.
So multiply the oxidation half reaction by 2 we get: $2A\ell \rightarrow 2A\ell^{3+} + 6e^-$
Multiply the reduction half reaction by 3 we get: $3Cu^{2+} + 6e^- \rightarrow 3Cu$
When **adding** both reactions the electrons cancel each other. Then we get:

$2A\ell(s) + 3Cu^{2+}(aq) \checkmark \rightarrow 2A\ell^{3+}(aq) + 3Cu(s) \checkmark \checkmark$

2.2.1 Aℓ/Aluminium ✓

2.1.2 The correct order of writing the cell notation is:
reducing agent | oxidised species || oxidising agent | reduced species

$A\ell \mid A\ell^{3+} \parallel Cu^{2+} \mid Cu$

2.1.3 $E^{o}_{cell} = E^{o}_{cathode} - E^{o}_{anode}$ ✓
$= 0,34$ ✓$- (-1,66)$ ✓
$= 2$ V ✓ (4)

[15]

EXERCISES

QUESTION 1

The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode **X** is shown below.

$$X(s) \mid X^{3+}(1\ mol{\cdot}dm^{-3}) \parallel Pb^{2+}(1\ mol{\cdot}dm^{-3}) \mid Pb(s)$$

1.1 Name the component of the cell represented by the double vertical lines (||) in the above cell notation. (1)

1.2 State the TWO standard conditions that are applicable to the $Pb^{2+}|Pb$ half-cell. (2)

1.3 Identify the oxidising agent in the above cell. (1)

1.4 The initial reading on a voltmeter connected across the electrodes of the above cell is 1,53 V. Identify metal **X** by calculating the standard reduction potential of the unknown metal **X**. (5)

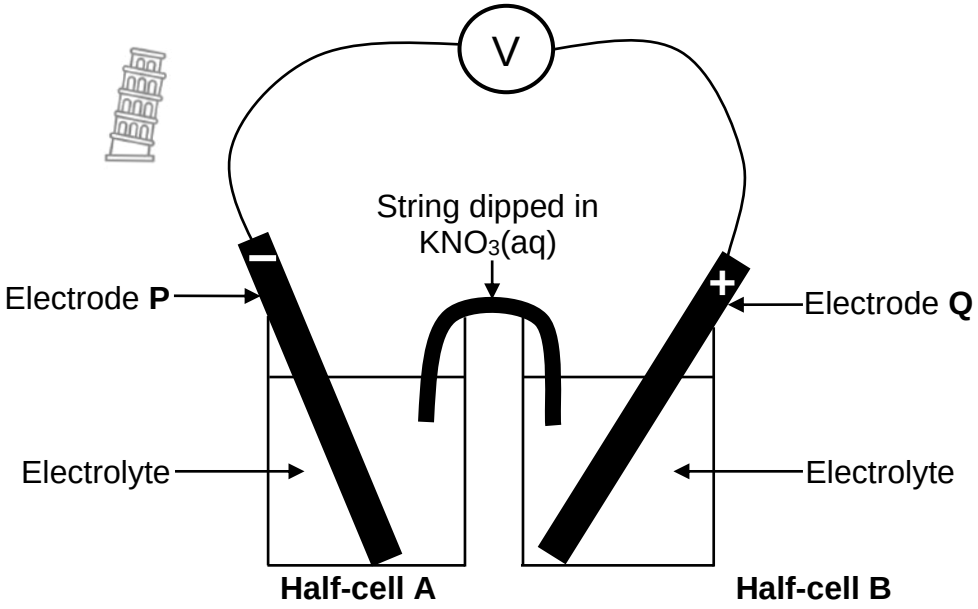
1.5 Write down the balanced equation for the net (overall) reaction taking place in this cell. Omit the spectator ions. (3)

1.6 Write down the value of the reading on the voltmeter when the cell reaction has reached equilibrium. (2)

[14]

QUESTION 2

Learners set up an electrochemical cell, shown in the simplified diagram below, using magnesium and lead as electrodes. Nitrate solutions are used as electrolytes in both half-cells.



2.1 What type of reaction (NEUTRALISATION, REDOX or PRECIPITATION) takes place in this cell? (1)

2.2 Which electrode, **P** or **Q**, is magnesium? Give a reason for the answer. (2)

2.3 Write down the:

2.3.1 Standard conditions under which this cell functions (2)

2.3.2 Cell notation for this cell (3)

2.3.3 NAME or FORMULA of the oxidising agent in the cell (1)

2.4 Calculate the initial emf of the cell above under standard conditions. (4)

[13]

QUESTION 3

Magnesium (Mg) reacts with a dilute hydrochloric acid solution, HCℓ(aq), according to the following balanced equation:

$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$

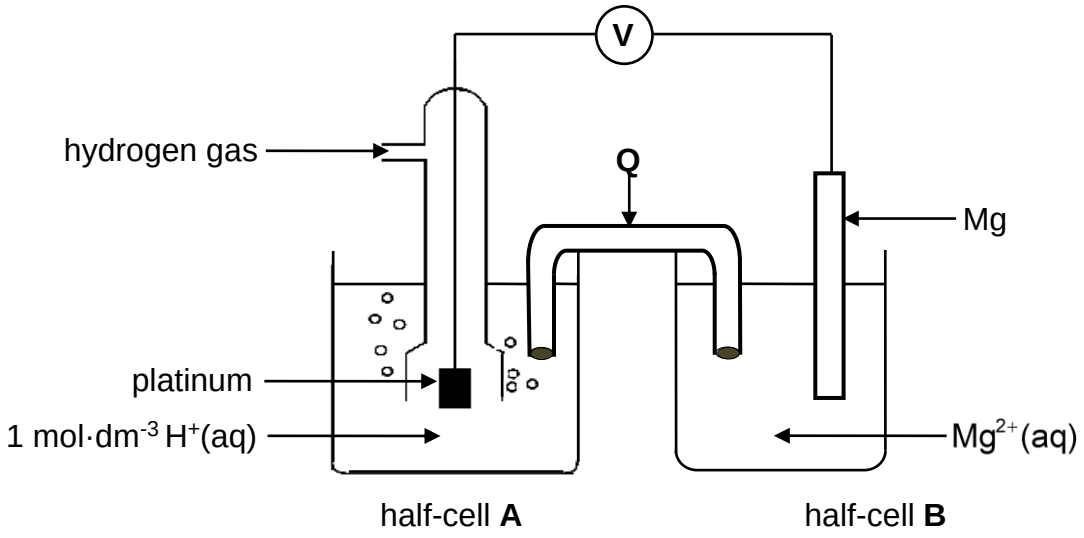
3.1 Give a reason why the reaction above is a redox reaction. (1)

3.2 Write down the FORMULA of the oxidising agent in the reaction above. (1)

It is found that silver does not react with the hydrochloric acid solution.

3.3 Refer to the relative strengths of reducing agents to explain this observation. (3)

The reaction of magnesium with hydrochloric acid is used in an electrochemical cell, as shown in the diagram below. The cell functions under standard conditions.



3.4 What is the function of platinum in the cell above? (1)

3.5 Write down the:

3.5.1 Energy conversion that takes place in this cell (1)

3.5.2 Function of **Q** (1)

3.5.3 Half-reaction that takes place at the cathode (2)

3.5.4 Cell notation of this cell (3)

3.6 Calculate the initial emf of this cell. (4)

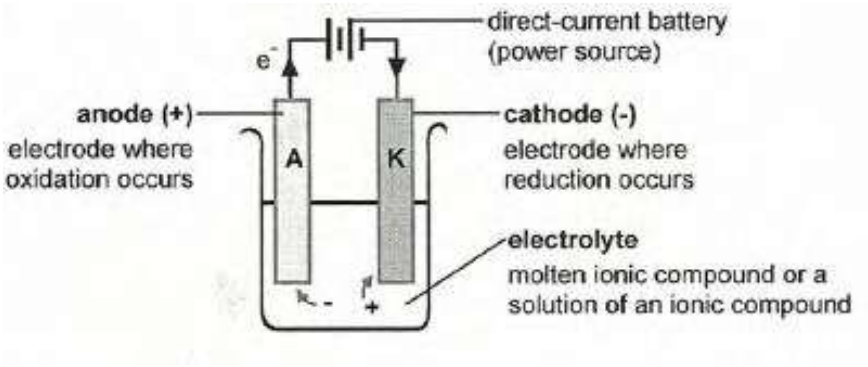
[17]

ELECTROLYTIC CELL

Electrolytic cell	a cell in which electrical energy is converted into chemical energy.

HOW TO IDENTIFY AN ELECTROLYTIC CELL:

- It will contain a *POWER SOURCE/ BATTERY* (electrical energy to chemical energy)
- **Positive terminal of battery will be your Anode!!**



APPLICATIONS OF ELECTROLYSIS

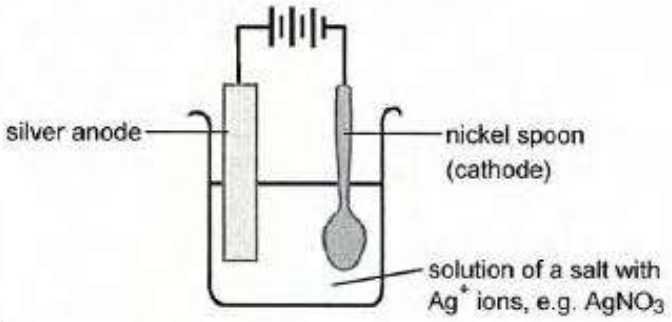
1. ELECTROPLATING

Electroplating is the process by which a metal object is coated with another metal to improve its appearance, to protect it or to give it other useful qualities.

Method:

- The *object that has to be coated* is the *cathode* (it is connected to the negative terminal of the battery).
- The *anode (connected to the + terminal)* consists of *the metal (X) with which you want to coat the object*, e.g. silver or copper.
- The *electrolyte* is a solution of a compound of X (metal salt containing X ions).

For example: A nickel spoon is coated with silver.



At the cathode

Silver ions (+) are attracted to the cathode (-) and reduced to silver metal. The spoon is coated with a layer of silver.

$$Ag^+(aq) + e^- \rightarrow Ag(s)$$

At the anode

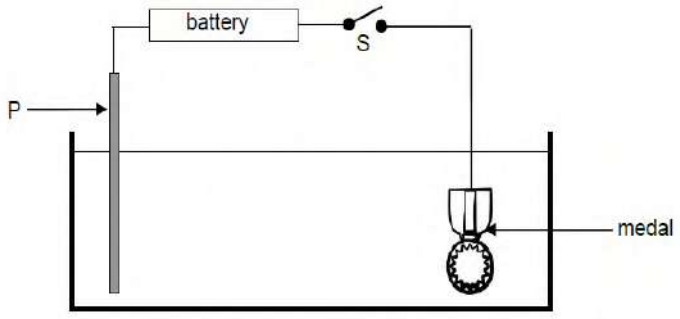
Silver atoms are oxidised to Ag+ ions (oxidation half-reaction).

$$Ag(s) \rightarrow Ag^+(aq) + e^-$$

WORKED EXAMPLE

QUESTION 1

The diagram below represents a cell that can be used to electroplate a tin medal with a thin layer of silver to improve its appearance.



1.1 Which one of **P** or the **MEDAL** is the anode in this cell? (1)

1.2 Write down the following:

1.2.1 NAME or SYMBOL of the element of which electrode **P** is composed (1)

1.2.2 NAME or FORMULA of the electrolyte that has to be used to achieve the desired results (1)

1.3 Switch **S** is now closed. Write down the visible changes that will occur at the following:

1.3.1 Electrode P (1)

1.3.2 The medal (1)

1.3 Write down the equation for the half-reaction to support the answer to QUESTION 1.3.2. (2)

1.4 How will the concentration of the electrolyte change during the electroplating process? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

1.5 You want to coat the medal with copper instead of silver. State TWO changes that you will make to the above cell to obtain a medal coated with copper. (2)
[10]

Solution

1.1 Anode is the one that undergoes oxidation. So Anode should be P which is made up of silver.
P ✓ (1)

1.2.1 Ag / Silver✓ (1)

1.2.2 Electrolyte must be any soluble solution of silver.
Silver nitrate / $AgNO_3$ ✓ (1)

1.3.1 Electrode P is the anode. It will oxidised and get thinner.
Silver /metal bar becomes smaller / thinner ✓ (1)

1.3.2 The arrangement is for the electroplating of the medal with silver. So:

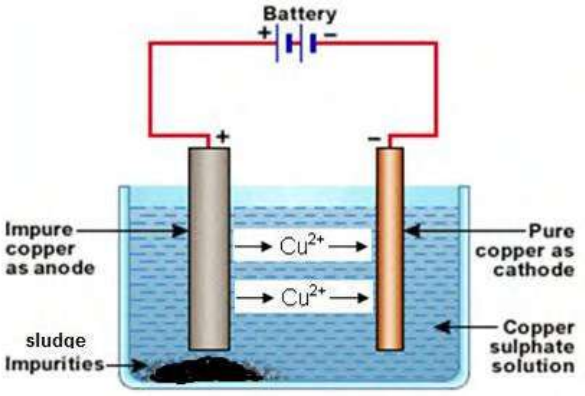
A (silver) layer forms on the medal. ✓ (1)

1.4 On the medal reduction of silver ions (Ag^+) takes place to have a coating of silver on it..
$Ag^+ + e^- \rightarrow Ag$ ✓✓ (2)

1.5 In electroplating the concentration of the electrolyte remains constant because the rate of oxidation equals the rate of reduction.
Remains the same. ✓ (1)

1.6 Replace the silver solution with a copper solution✓
Replace the silver electrode with a copper.✓ (2)
[10]

2. PURIFICATION OF COPPER / ELECTRO REFINING OF COPPER



At the anode
The impure copper undergoes **oxidation** and enters the solution as ions.

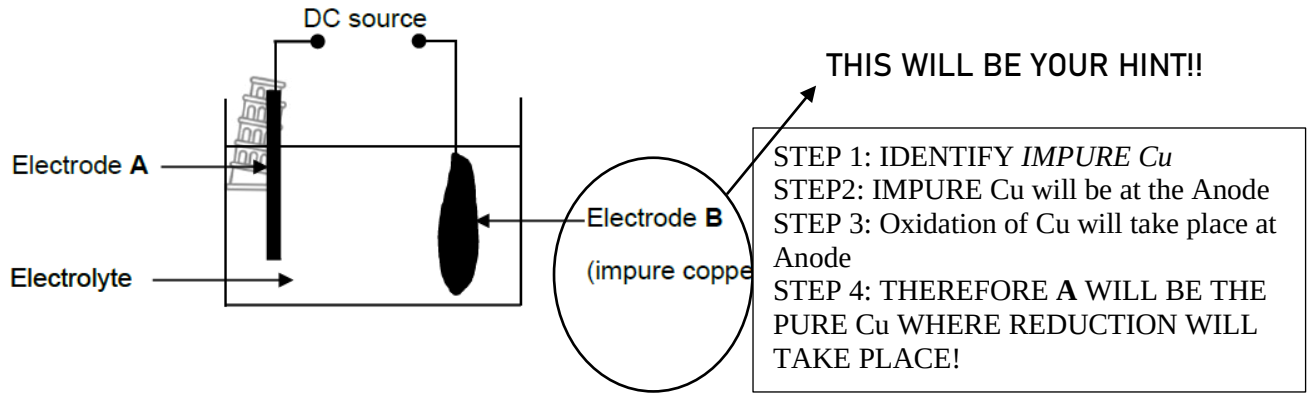
$$\mathbf{Cu \rightarrow Cu^{2+} + 2e^-}$$

Some impurities will also be oxidised (go in solution, while others, such as silver, platinum and gold, which are stronger oxidising agents, will not be oxidised that easily). *They sink to the bottom* and will be recovered because they are valuable products. *These impurities are known as mud/slime*.

At the cathode
Cu^{2+} ions are attracted from the solution to the pure copper cathode.
Here **reduction** takes place to form pure copper: $\mathbf{Cu^{2+} + 2e^- \rightarrow Cu}$

QUESTION 2

The simplified diagram below represents an electrochemical cell used for the purification of copper



2.1 Define the term *electrolysis*. (2)

2.2 Give a reason why a direct-current (DC) source is used in this experiment. (1)

2.3 Write down the half-reaction which takes place at electrode **A**. (2)

3.4 Due to small amounts of zinc impurities in the impure copper, the electrolyte becomes contaminated with Zn^{2+} ions.
Refer to the attached Table of Standard Reduction Potentials to explain why the Zn^{2+} ions will not influence the purity of the copper obtained during this process. (3)
[8]

Solution

2.1 The chemical process in which electrical energy is convereted into chemical energy. ✓✓ (2)

2.2 To prevent the anode and cathode from swapping.✓ (1)

2.3 Copper ions is reduced at electrode A.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ ✓✓ (2)

2.4 In other words the question is asking why Zn^{2+} is not reduced to Zn. The reason is Cu^{2+} is a stronger oxidising agent than Zn^{2+}.

Cu^{2+} is a stronger osidising agent than Zn^{2+}. ✓
Cu^{2+} will reduce to Cu.✓ (3)
[8]

3. ELECTROLYSIS OF $CuC\ell_2$

Changes at the anode

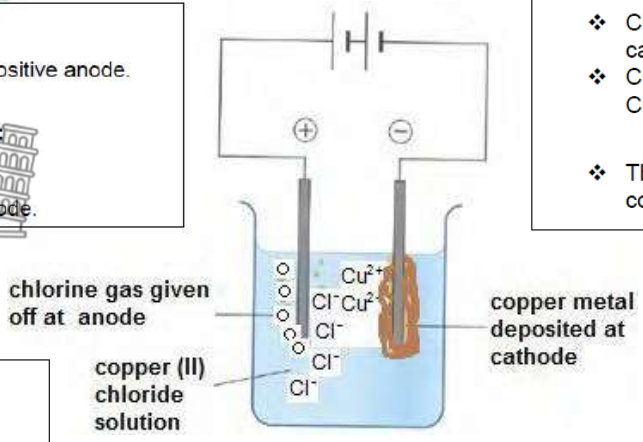
- The $C\ell^-$ ions are attracted to the positive anode.
- $C\ell^-$ ions lose electrons.
- The loss of electrons is **oxidation**:

  $2\ C\ell^-\ (aq) \rightarrow C\ell_2\ (g) + 2e^-$
- Chlorine gas is given off at the anode.

Changes at the cathode

- Cu^{2+} ions are attracted to the negative cathode.
- Cu^{2+} ions receive two electrons to produce Cu.

  $Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)$
- The mass of the cathode increases as copper is formed.

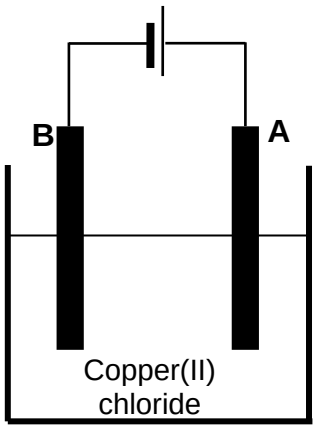


Changes of the electrolyte

- The blue colour of the electrolyte gradually disappears as the blue Cu^{2+} ions are reduced.

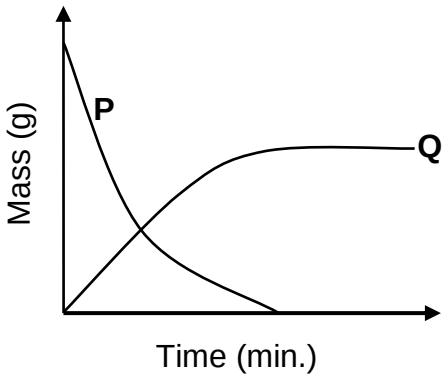
QUESTION 3

The electrochemical cell below is set up to demonstrate the purification of copper.



3.1 Write down the type of electrochemical cell illustrated above. (1)

The graphs below show the change in mass of the electrodes whilst the cell is in operation.



3.2 Define a *reducing agent* in terms of electron transfer. (2)

3.3 Which graph represents the change in mass of electrode **A**? (1)

3.4 Write down the half-reaction that takes place at electrode **A**. (2)

3.5 Electrodes **A** and **B** are now replaced by graphite electrodes. It is observed that chlorine gas ($C\ell_2$) is released at one of the electrodes.

At which electrode (**A** or **B**) is chlorine gas formed? Fully explain how it is formed. (3)

[9]

Solution

3.1 Electrolytic cell✓ (1)

3.2 The substance/species which loses electrons. ✓ ✓ (2)

3.3 Electrode A is connected to the positive terminal. Hence it is the anode. It is undergoing oxidation and loses mass.
P✓ (1)

3.4 Electrode A (impure copper) undergoes oxidation.

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ ✓✓ (2)

3.5 A ✓
$C\ell^-$ ions move to the positive electrode/anode where they are oxidised to $C\ell_2$. ✓✓ (3)

[9]

ANSWERS TO EXERCISES

NEWTONS' LAWS

QUESTION 1

1.1.1 When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body. (2)

1.1.2

For 2,5 kg block

$T = mg$ ✓

$\therefore T = (2,5)(9,8)$ ✓

$= 24,5$ N ✓ (3)

1.1.3

For mass M

$f_s = \mu_s N$ ✓

$\therefore N = \frac{24,5}{0,2}$ ✓ $= 122,5$ N

$N = Mg = 122,5$ N

$M(9,8) = 122,5$ N ✓

$M = 12,5$ kg ✓ (5)

1.1.4

For the 5 kg block

$f_k = \mu_k N$

$f_k = (0,15)(5)(9,8)$ ✓

$= 7,35$ N

$F_{net} = ma$

$T - f_k = ma$ } ✓

$T - 7,35 = 5a$ ✓

$T = 5a + 7,35$ --- (1)

For the 2,5 kg block

$w - T = ma$

$(2,5)(9,8) - T = 2,5\,a$ ✓----(2)

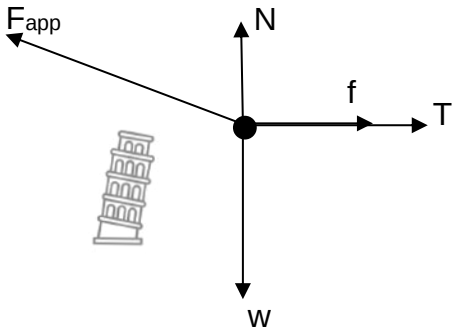
Substitute (1) in (2)

$17,15 = 7,5\,a$

$a = 2,29$ m·s^{-2} ✓ (5)

QUESTION 2

2.1 (5)



2.2.1

$F_{60y} = F_{60} \sin\theta$
$F_{60y} = 60\sin 10^o$
$= 10,42$ N✓ (2)

2.2.2

$F_{60x} = F_{60} \cos\theta$ ✓
$F_{60x} = 60\cos 10^o$
$= 59,09$ N✓ (2)

2.3 Acceleration of an object is directly proportional to the net force and inversely proportional to the mass. (2)

2.4

$N = mg - F_{60y}$
$N = \{5(9,8) - 10,42\}$ ✓
$= 38,58$ N✓ (2)

2.5

For 2 kg body

$F_{net} = ma$
$T - mg = ma$ ✓

$T - 2(9,8) = 2a.$
$T - 19,6$ ✓$= 2a$.....(1)

For 5 kg body ✓

$F_{60x} - (f+T) = m_8 a$
$60\cos 10^o - (f+T) = 5a.$
$60\cos 10^o - [(\mu_k N)$ ✓ $+T)] = 5a..$
$59,09 - (0,5 \times 38,58) - T$ ✓$= 5a$

$39, 8 - T = 5a$.....(2)
$a = 2,89\ ms^{-2}$

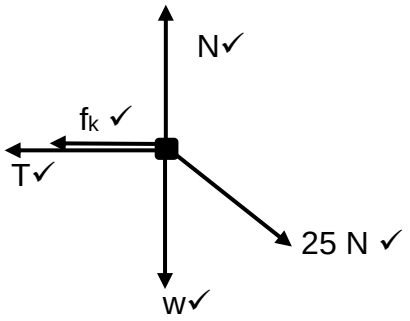
$T - 19,6 = 2\ (2,89)$ ✓
$T = 25,38$ N✓ (7)

QUESTION 3

3.1 When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body. (2)

3.2
$f_k = \mu_k N$✓ $= \mu_k mg$
$= (0,15)(3)(9,8)$✓
$= 4,41$ N✓ (3)

3.3



3.4.1
OPTION 1
$f_k = \mu_k N = \mu_k(25\sin 30^o + mg)$
$= 0,15[(25\sin 30^o)$✓ $+ (1,5)(9,8)$✓$]$
$= 4,08$ N✓ (3)

3.4.2
For the 1,5 kg block
$F_{net} = ma$
$F_x + (-T) + (-f_k) = ma$ ✓
$25\cos 30^o - T - f_k = 1,5a$
$(25\cos 30^o - T) - 4,08$ ✓$= 1,5a$
$17,571 - T = 1,5a$ …….(1) ✓either one

For the 3 kg block
$T - f_k = 3a$
$T - 4,41$✓ $= 3a$ ……(2)
$13,161 = 4,5\ a$
$a = 2,925$ m·s^{-2}
$T = 13,19$ N ✓ (5)
[18]

MOMENTUM

QUESTION 1

1.1 The total linear momentum in a closed system✓ remains constant./is conserved✓ (2)

1.2 $\sum p_i = \sum p_f$✓

$(m_1 + m_2)v_i = m_1v_{1f} + m_2v_{2f}$

0✓ $= (0,4)v_{1f} + 0,6\ (4)$✓

$v_{1f} = -\ 6\ m\cdot s^{-1}$

$= 6\ m\cdot s^{-1}$ to the left✓ (4)

[6]

QUESTION 2

2.1 The total linear momentum in a closed system✓ remains constant./is conserved✓ (2)

2.2 **East as positive/*Oos as positief***

$\sum p_{before/voor} = \sum p_{after/na}$

$m_Av_{A(before/voor)} + m_Bv_{B(before/voor)} = m_Av_{A(after/na} + m_Bv_{B(after/na}$ ✓Any one/*Enige een*

$(0,20)(+10) + (0,30)(+5)$ ✓$= (0,20)(+2,5) + (0,3)v_{B(after/na)}$ ✓

$V_{B(after/na)} = +10,00\ m\cdot s^{-1}$

$V_{B(after/na)} = 10,00\ m\cdot s^{-1}$ ✓ east/*oos* ✓ (5)

[7]

QUESTION 3

3.1 The product of an object's mass and velocity✓✓ (2)

3.2 **RIGHT AS POSITIVE**

$\Sigma p_i = \Sigma p_f$ OR/OF $\Sigma p_{(before)} = \Sigma p_{(after)}$

$m_Av_{Ai} + m_Bv_{Bi} = m_Av_{Af} + m_Bv_{Bf}$

$m_Av_{A(before)} + m_Bv_{B(before)} = m_Av_{A(after)} + m_Bv_{B(after)}$

$m_Av_{Ai} + m_Bv_{Bi} = (m_A + m_B)v_f$

$m_Av_{A(before)} + m_Bv_{B(before)} = (m_A + m_B)v_{(after)}$

✓ Any one

$(7,2)(0,4) + (0)$✓ $= (7,2 + 5,3)v_f$ ✓

$v_f = 0,23\ m\cdot s^{-1}$ regs✓ (4)

[6]

DOPPLER EFFECT

QUESTION 1

1.1.1 Frequency (of sound detected by the listener (observer))✓ (1)

1.1.2 A change in detected frequency, as a result of the relative motion between a source and a listener.✓✓ (2)

1.1.3 Away✓
Detected frequency of source decreases✓ (2)

1.1.4 **EXPERIMENT**

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR/*OF*** $f_L = \frac{v}{v + v_s} f_s$ ✓

$874 \overset{✓}{=} \frac{v}{v+10} \overset{✓}{(900)}$ ✓

$v = 336{,}15\ m \cdot s^{-1}$✓ (5)

1.2 Away from the Earth✓ (1)

[11]

QUESTION 2

2.1.1 Frequency (of sound detected by the listener (observer))✓ (1)

2.1.2 $v = f\lambda$ ✓
$\underline{340 = f(0{,}28)}$ ✓
$f_s = 1\ 214{,}29$ Hz ✓ (3)

2.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$f_L = \frac{v}{v - v_s} f_s$

$f_L = (\frac{340}{340 - 30}) 1214{,}29$✓

$= 1\ 331{,}80$ Hz✓ (5)

2.1.4 Decreases✓ (1)

2.2 The spectral lines of the star are/should be shifted towards the lower frequency ✓ end, which is the red shift. ✓ (2)

[13]

QUESTION 3

3.1.1 $v = f\lambda$ ✓

$\lambda = \frac{340}{520}$

$= 0,65$ m ✓ (2)

3.1.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$f_L = \frac{v}{v - v_s} f_s$

$f_L = \frac{340}{(340 - 15)} (520)$ ✓ ✓

$f_L = 544$ Hz

$v = f\lambda$ ✓

$\lambda = \frac{340}{544}$ ✓

$= 0,63$m ✓ (6)

3.2 The wavelength in QUESTION 3.1.2 is shorter because the waves are compressed as they approach the observer. ✓✓ (2)

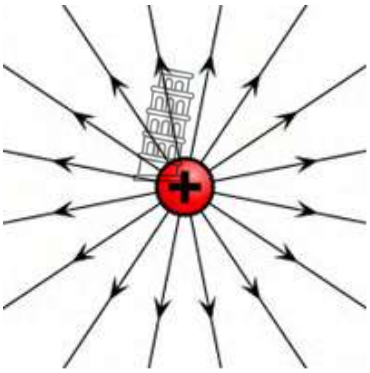
3.3 The red shift occurs when the spectrum of a distant star moving away from the earth is shifted toward the red end of the spectrum.✓✓ (2)

[12]

ELECTROSTATICS

QUESTION 1

1.1



Shape (radial)✓

Correct direction ✓

(2)

1.2 An *electric field* is a region of space in which an electric charge experiences a force✓✓ (2)

1.3 $Q=ne$✓

$Q=(3{,}125\times10^{10})(1{,}6\times10^{-19})$✓

$Q=+5\times10^{-9}C$✓ (3)

1.4 $E=\frac{kQ}{r^2}$✓

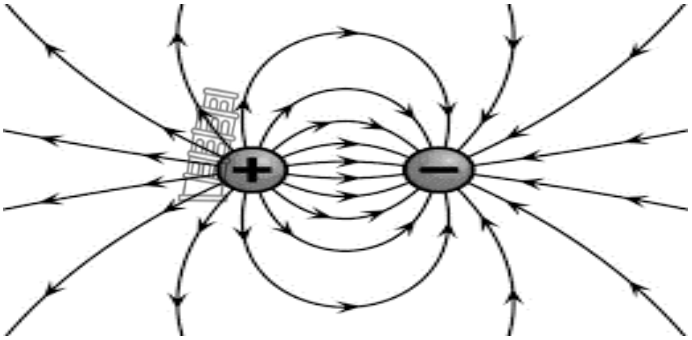
$E=\frac{(9{,}0\times10^{9})(5\times10^{-9})}{(0{,}8)^2}$✓

$E=70{,}31\ N\cdot C^{-1}$ away from the charge✓ (3)

[10]

QUESTION 2

2.1



✓ shape

✓direction

✓lines don't cross, touch surface (3)

2.2 $E = k\frac{Q}{r^2}$ ✓

$E_2 = \frac{(9\times10^{9})(2\times10^{-6})}{(0{,}25)^2}$ ✓

$= 4{,}61 \times 10^{5}\ NC^{-1}$ to the east

$E_{-8} = \frac{(9\times10^{9})(8\times10^{-6})}{(0{,}15)^2}$ ✓

$= 3{,}2 \times 10^{6}\ N\cdot C^{-1}$ to the east

$E_X = E_2 + E_{(-8)}$

$= (4{,}61 \times 10^{5} + 3{,}2 \times 10^{6})$ ✓

$= \underline{3{,}66 \times 10^{6}\ N\cdot C^{-1}}$ ✓ to the east✓ (6)

2.3 $F_E = QE$✓

$= (-2 \times 10^{-9})\ (\underline{3{,}66 \times 10^{6}})$✓

$= -7{,}32 \times 10^{-3}$ N

$= 7{,}32 \times 10^{-3}$ N✓ <u>to the west</u>✓ (4)

[10]

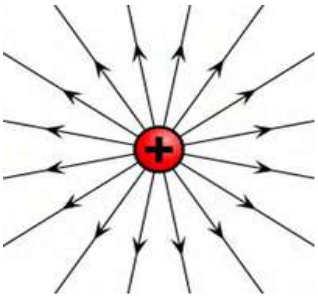
QUESTION 3

3.1 Positive/Positief.✓ (1)

3.2 Q = ne ✓
$Q = 938(1,6 \times 10^{-19}\ C)$✓ **OR/*OF*** $Q = 938(1,6 \times 10^{-19})$
$Q = 1,50 \times 10^{-16} C$ ✓
(3)

3.3 The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. (2)

3.4



Marking criteria/ *Nasienkriteria*	
Shape (radial)/*Vorm (radiaal)*	✓
Correct direction/*Korrekte rigting*	✓

(2)

3.5 At **A**.✓
The distance from A to the charged sphere **X** is smaller than the distance from B to the charged sphere X ✓and the electric field at a point due to a point charge is inversely proportional to the square distance between the point and the charge ($E \propto \frac{1}{d^2}$) ✓ (3)

3.6.1 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product (of the magnitudes) of the charges✓ and inversely proportional to the square of the distance between them.✓ (2)

3.6.2 $F = \frac{KQ_1Q_2}{r^2}$ ✓

$F_{YonX} = \frac{9 \times 10^9 \times (1,5 \times 10^{-16} \times (2,8 \times 10^{-16})}{(0,03)^2}$ ✓

$F_{YonX} = 4,2 \times 10^{-19}$N to the right

$F = \frac{KQ_XQ_Z}{r^2}$

$F_{ZonX} = \frac{9 \times 10^9 \times (1,5 \times 10^{-16} \times (3,2 \times 10^{-16})}{(0,01)^2}$ ✓

$F_{ZonX} = 43,2 \times 10^{-19}$ N to the right

Positive to the right

$\vec{F}_{net} = \vec{F}_{YonX} + \vec{F}_{ZonX}$ **OR/*OF*** $F_{net} = F_{YonX} + F_{ZonX}$

$\vec{F}_{net} = 4,2 \times 10^{-19} + 43,2 \times 10^{-19}$✓

$\vec{F}_{net} = 47,4 \times 10^{-19}$N to the right✓

(5)
[18]

ELECTRODYNAMICS

QUESTION 1

1.1 Electromagnetic induction✓ (1)

1.2 Rotate the coil faster/Increase the number of coils/ Increase the strength of the magnetic field. (1)

1.3 Slip rings✓ (1)

1.4.1 The rms potential difference is the DC potential difference which dissipates/produces the same amount of energy as an equivalent AC potential difference. (2)

1.4.2
$$V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$$
$$= \frac{339,45}{\sqrt{2}} \checkmark$$
$V_{rms} = 240,03\ V$ ✓ (3)
[8]

QUESTION 2

2.1.1
$$P_{av} = \frac{V^2_{rms}}{R} \checkmark$$
$$100 \checkmark = \frac{\left(\frac{340}{\sqrt{2}}\right)^2}{R} \checkmark$$
$R = 578\ \Omega$✓ (5)

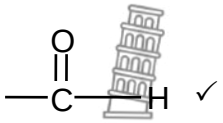
2.1.2
$$P_{av} = I_{rms}V_{rms} \checkmark$$
$$100 = I_{rms}\frac{340}{\sqrt{2}} \checkmark$$
$$I_{rms} = \frac{100}{\frac{340}{\sqrt{2}}}$$
$= 0,417\ A$ ✓ (3)
[8]

ORGANIC CHEMISTRY- NOMENCLATURE

QUESTION 1

1.1

1.1.1 B ✓ (1)

1.1.2  ✓ (1)

1.1.3 C_nH_{2n-2} ✓ (1)

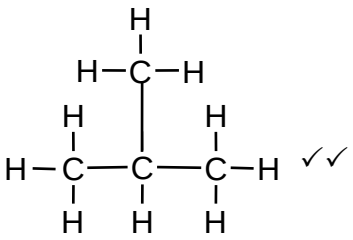
1.1.4 4-ethyl-5-methylhept-2-yne / 4-ethyl-5-methyl-2-heptyne

1.1.5 Butan-2-one / 2-butanone / Butanone

1.2

1.2.1 Alkanes ✓ (1)

1.2.2 ✓ ✓
2-methylpropane

 ✓✓ (4)

1.2.3 Chain ✓ (1)

[14]

QUESTION 2

2.1

2.1.1 A **OR** D ✓ (1)

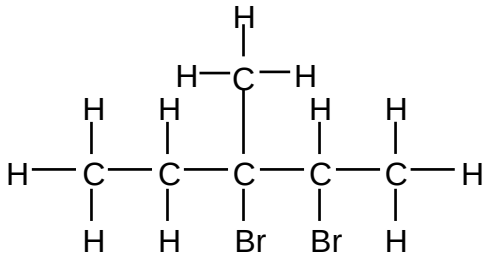
2.1.2 B ✓ (1)

2.1.3 E ✓ (1)

2.1.4 D ✓ (1)

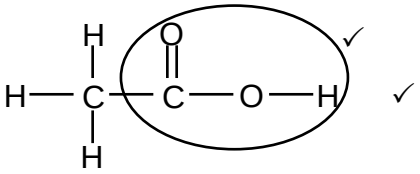
2.2

2.2.1



(3)

2.2.2



(2)
[8]

QUESTION 3

3.1

3.1.1 B ✓ (1)

3.1.2 E ✓ (1)

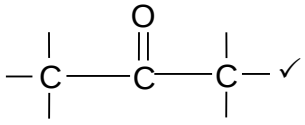
3.1.3 A ✓ (1)

3.2

3.2.1 4-chloro-2,5-dimethylheptane (3)

3.2.2 2-methyl✓propan-1-ol ✓ (2)

3.2.3



(1)
[9]

PHYSICAL PROPERTIES

QUESTION 1

1.1 A bond/an atom or a group of atoms ✓ that determine(s) the (physical and chemical) properties of a group of organic compounds. ✓ (2)

1.2

1.2.1 D / ethanoic acid ✓

Lowest vapour pressure. ✓ (2)

1.2.2 A / butane ✓ (1)

1.3
- Between molecules of **A** / butane / alkanes are London / induced dipole / dispersion forces. ✓
- Between molecules of **B** / propan-2-one / ketones are dipole-dipole forces ✓ in addition to London / induced dipole / dispersion forces.
- Intermolecular forces in **A** are weaker than those in **B**. / Less energy is needed in **A** to break/overcome intermolecular forces. ✓ (3)

1.4 London forces/dispersion forces/induced dipole forces/dipole-dipole forces. ✓
OR
A and **B** do not have hydrogen bonding./**C** and D have hydrogen bonding. (1)

1.5
- **D** has more sites for hydrogen bonding than **C** / forms dimers / is more polar than **C**. ✓
- **D** has stronger / more intermolecular forces / dipole-dipole forces. ✓

  OR
  D needs more energy to overcome/break the intermolecular forces. (2)

[11]

QUESTION 2

4.1 Saturated✓
- It has ONLY single bonds. ✓ (2)

2.2
2.2.1 -42 °C ✓ (1)

2.2.2 78 °C ✓ (1)

2.3
- Between molecules of C/propane are London forces/dispersion forces/induced dipole forces. ✓
- Between molecules of E/ethanol are London forces/dispersion forces/induced dipole forces and hydrogen bonds. ✓
- Hydrogen bonds/Forces between alcohol molecules are stronger.

OR

More energy is needed to overcome hydrogen bonds/forces between alcohol molecules than London forces/dispersion forces/induced dipole forces. ✓ (3)

2.4 Decrease✓
From A to D:
- Chain length/molecular mass/molecular size increases. ✓
- Strength of intermolecular forces increases. ✓
- More energy needed to overcome/break the intermolecular forces. ✓ (4)

2.5 Higher than✓ (1)
[12]

QUESTION 3

3.1 The temperature at which the vapour pressure equals atmospheric pressure. ✓✓ (2)

3.2 Flammable / Catch fire easily. ✓ (1)

3.3
3.3.1 Use straight chain ✓ primary alcohols ✓ (2)

3.3.2.
- **Structure**

Chain length / more C atoms in chain / molecular size / molecular mass / surface area increases from top to bottom / butan-1-ol to hexan-1-ol. ✓
- **Intermolecular forces**

Intermolecular forces / Van der Waals forces / London forces / dispersion forces increases from top to bottom / butan-1-ol to hexan-1-ol. ✓
- **Energy**

Energy needed to overcome / break intermolecular forces increases from top to bottom / butan-1-ol to hexan-1-ol. ✓

3.4 Remains the same✓ (1)

3.5

3.5.1 Functional group / Type of homologous series ✓ (1)

3.5.2

- **Type of intermolecular forces**

Between molecules of aldehyde / hexanal are dipole-dipole forces. ✓

- Between molecules of alcohols / hexan-1ol are (in addition to dipole-dipole forces and London forces) hydrogen bonds. ✓
- **Strength of intermolecular forces**

  Dipole-dipole forces are weaker than hydrogen bonds. ✓

  OR/*OF*

  Hydrogen bonds are stronger than dipole-dipole forces.
- **Energy**

  More energy needed to overcome / break intermolecular forces in hexan-1-ol. ✓

  OR

  Less energy needed to overcome / break intermolecular forces in hexanal.✓ (4)

[14]

ORGANIC REACTIONS

QUESTION 1

1.1

1.1.1 addition✓ (1)

1.1.2 elimination✓ (1)

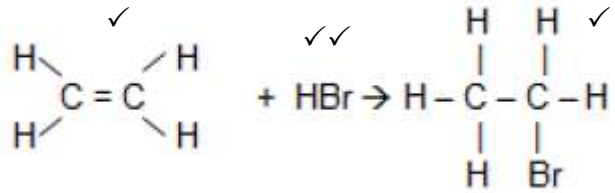
1.1.3 substitution ✓ (1)

1.2

1.2.1 water✓ (1)

1.2.2 (dilute)sulphuric acid / (dilute)phosphoric acid ✓ (1)

1.3



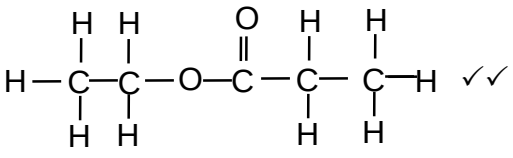
(4)

1.4

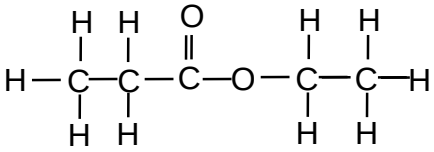
1.41 propanoic acid ✓✓

1.4.2 esterification ✓

1.4.3



✓✓ **OR/*OF***



(2)

[14]

QUESTION 2

2.1

2.1.1 Addition / hydration ✓ (1)

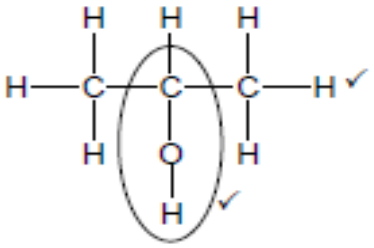
2.1.2 Substitution / halogenation / chloronation✓ (1)

2.1.3 Elimination / dehydration ✓ (1)

2.2 (1)

2.2.1 H_2SO_4 / H_3PO_4 ✓

2.2.2

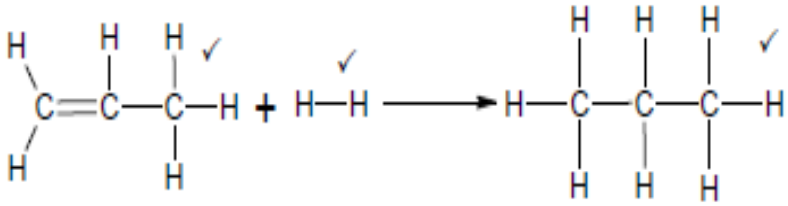


(2)

2.3

2.3.1 Hydrogenationtion✓

2.3.2



(3)

2.4

2.4.1 2-chloro✓propane ✓ (2)

2.4.2 Sodium hydroxide (dil) / Potassium hydroxide (dil) ✓ (1)

2.4.3 <u>Dilute base</u>✓
<u>Mild heat</u> ✓ (2)

[15]

RATE OF REACTION

QUESTION 1

1.1 reaction rate✓✓ (2)

1.2 Between t = 100 s and t = 200 s the gradient is decreasing because the reaction rate decreases✓as zinc is gradually being used up. ✓ (2)

1.3 After t=300 s the reaction has stopped ✓because the zinc has been completely used up. ✓ (2)

1.4 $$\text{rate of reaction} = \frac{\Delta \text{volume } (H_2)}{\Delta \text{time}}$$

$$= \frac{150 \quad 0}{100 \quad 0} \checkmark\checkmark$$

$$= 1{,}5 \text{ cm}^3\text{s}^{-1}. \checkmark$$ (3)

1.5 High temperature means that reactant particles have more kinetic energy ✓ (E_K) therefore there will be more effective collisions per unit time, ✓ thus reaction rate increases. ✓ (3)

1.6 1 mol of H_2 ⟶ 22,4 dm^3 ✓
x mol of H_2 ⟶ 0,25 dm^3 ✓
$\therefore x$ = 0,011mol

From the equation 1mol of Zn produce 1mol of H_2. ✓(ratio)

Mass Zn = nM

m = nM

= (0,011)(65,4) ✓

= 0,73 g✓ (5)

[17]

QUESTION 2

2.1 Temperature ✓ (1)

2. 2 • Change in concentration ✓ of products/reactants per (unit) time. ✓ (2)

2.3 14 (min) ✓✓ (2)

2.4

2.4.1 Graph **B** ✓
(Experiment **3)** has the highest (acid) concentration/more particles/higher number of moles. ✓ (2)

2.4.2 (Graph **C** ✓
(Experiment 5) is at highest temperature/more particles with sufficient kinetic energy. ✓ (2)

2.5

2.5.1 Speeds up the reaction./Increases the reaction rate./Provides alternate pathway./Lowers the (net) activation energy. ✓ (1)

2.5.2 Equal to✓ (1)

2.6

$$n(Zn) = \frac{m}{M}$$

$$= \frac{1,5}{65}\checkmark$$

$$= 0,023 \text{ mol}$$

$$\text{rate} = -\frac{\Delta n}{\Delta t}\checkmark$$

$$= -\left(\frac{0 - 0,023}{14\checkmark - 0}\right)$$

$$= 1,65 \times 10^{-3} \text{ (mol·min}^{-1}\text{)} \checkmark$$

(4)
[15]

QUESTION 3

3.1 • Change in concentration of reactant/product per (unit) time.✓✓ (2)

3.2

3.2.1 Surface area/state of division✓ (1)

3.2.2 **ANY ONE**
Concentration of the acid✓
Temperature of the acid
Mass of the sodium carbonate (1)

3.3 Carbon dioxide/CO_2 ✓ (1)

3.4 90 seconds ✓ (1)

3.5 Greater than ✓

- In experiment 2, the sodium carbonate has a greater surface area which means more reaction sites. ✓
- There will be more effective collisions per unit time in experiment 2 than in experiment 1. ✓ (3)

3.6

3.6.1 Mass of CO_2 formed = 150 -145,60 ✓
= 4,4 g

$n = \frac{m}{M}$

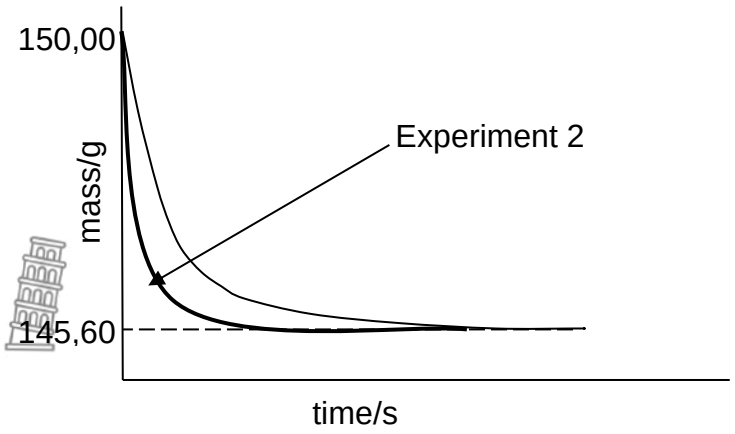
$n = \frac{4,4}{44}$ ✓

n = 0,1moles

n (CO_2) : n (Na_2CO_3) = 1:1✓

m (Na_2CO_3) = n x M
= (0,1)(106)✓
= 10,6 g✓ (5)

3.6.2



Marking Criteria

- Graph for experiment 2 should have a steeper gradient than experiment 1. ✓
- Time for reaction to come to completion must be shorter. ✓ (2)

[16]

CHEMICAL EQUILIBRIUM

1.1 $$K_C = \frac{[NOBr]^2}{[NO]^2[Br_2]}$$

1.2 $$K_C = \frac{[NO_2]^2}{[N_2O_4]}$$

1.3 $$K_C = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

1.4 $$K_C = \frac{[CO][H_2O]}{[H_2][CO_2]}$$

1.5 $$K_C = \frac{[O_2]}{[O_3]^2}$$

We do not include Br_2 and BrO_2 in Kc expression as they are in liquid and solid phase respectively)

GALVANIC CELLS

QUESTION 1

1.1 Saltbridge✓ (1)

1.2 Concentration of the electrolyte- 1 mol·dm^{-3} ✓
Temperature- 25 °C/298 K ✓ (2)

1.3 Pb^{2+} ✓ (1)

1.4 $E^{o}_{Cell} = E^{o}_{Cathode} - E^{o}_{anode}$ ✓
1,53 ✓= (-0,13) ✓- E^{o}_{anode}
E^{o}_{anode} = -1,66 V ✓
∴ unknown metal X is Aℓ✓ (5)

1.5 $2A\ell + 3Pb^{2+} \rightarrow 2A\ell^{3+} + 3Pb$

(reactants✓; products✓; balancing) ✓ (3)

1.7 0 V ✓✓ (2)
[14]

QUESTION 2

2.1 Redox (reaction)✓ (1)

2.2 P ✓
Negative electrode/Mg is a stronger reducing agent/is oxidized/release electrons. ✓ (2)

2.3
2.3.1 Temperature 25 °C/298 K. ✓
Concentration 1 mol·dm^{-3}. ✓ (2)

2.3.2 $Mg(s) \mid Mg^{2+}(aq)$ ✓✓ $\| Pb^{2+}(aq) \mid Pb(s)$ ✓ (3)

2.3.3 $Pb^{2+}/Pb(NO_3)_2$/lead(II) ions/lead(II)nitrate ✓ (1)

2.4 $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓
= -0,13 ✓ – (-2,36) ✓
= 2,23 V ✓ (4)
[13]

QUESTION 3

3.1 Electrons are transferred✓ (1)

3.2 H^+ ions ✓ (1)

3.3 Ag is a weaker reducing agent ✓(than H_2) and will not be oxidised ✓to Ag^+ ✓

OR/*OF*

H_2 is a stronger reducing agent ✓ (than Ag) and will be oxidised ✓ to H^+.✓ (3)

3.4 Electrode/Conductor of electrons (in hydrogen half-cell) ✓ (1)

3.5

3.5.1 Chemical energy to electrical energy ✓ (1)

3.5.2 Provides path for movement of ions./Completes the circuit./Ensures electrical neutrality in cell. ✓ (1)

3.5.3 $2H^+ + 2e^- \rightarrow H_2$ ✓✓ (2)

3.5.4 $Mg(s)$ ✓ | $Mg^{2+}(aq)$ ✓ || $H^+(aq)$ | $H_2(g)$ ✓ | Pt (3)

3.6

$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓

= 0,00 ✓ – (-2,36) ✓

= 2,36 V ✓ (4)

[**17**]