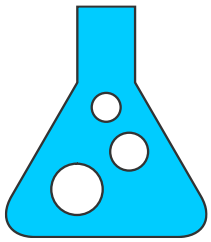
TELEMATIC SCHOOLS PROJECT

2025 SUBJECT WORKBOOK
Grade 12



PHYSICAL SCIENCES

A joint initiative between the Western Cape Education Department and Stellenbosch University.

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BROADCAST SESSIONS

GRADE 12 **PHYSICAL SCIENCES**

Session	Date	Time	Topic
1	**19/02/2025**	**16h00-17h00**	**Momentum**
2	02/06/2025	16h00-17h00	Rate of reactions
3	**13/08/2025**	**15h00-16h00**	**Electric circuits**

SESSION 1 | MOMENTUM

Momentum

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

Newton's second law of motion in terms of momentum

- State Newton's second law of motion in terms of momentum: The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force.
- Express Newton's second law of motion in symbols: $F_{net} = \frac{\Delta p}{\Delta t}$
- Explain the relationship between net force and change in momentum for a variety of motions.
- Calculate the change in momentum when a resultant/net force acts on an object and its velocity:
    - Increases in the direction of motion, e.g. 2nd stage rocket engine fires
    - Decreases, e.g. brakes are applied
    - Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from

SESSION 1 | MOMENTUM

Impulse

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

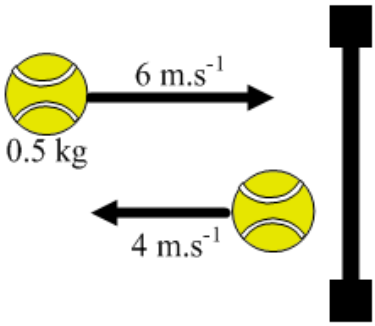
Conservation of momentum and elastic and inelastic collisions

- Explain what is meant by a *system* (in Physics).
- Explain (when working with systems) what is meant by *internal* and *external forces*.
- Explain what is meant by *an isolated system* (in Physics) i.e. a system on which the net external force is zero.

  An isolated system excludes external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.
- State the principle of conservation of linear momentum: The total linear momentum of an isolated system remains constant (is conserved).
- Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.

Distinguish between *elastic collisions* and *inelastic collisions* by calculation

Example: A ball, mass 0.5 kg, initially moves to the right at 6 $m.s^{-1}$ and bounces against a vertical wall. The ball leaves the wall with a velocity of 4 $m.s^{-1}$as indicated in the sketch. Ignore the effects of gravity on the ball. Calculate the change in momentum of the ball.



Choosing towards the right (towards the wall) as positive, the solution is as follows:

$\Delta p = p_f - p_i$

$= mv_f - mv_i$

$= 0,5(-4-6)$

$= -5\ kg.m.s^{-1}$

The chance in momentum is 5 $kg.m.s^{-1}$ to the left or (away from the wall)

Conservation of linear momentum states: *The total linear momentum of an isolated system remains constant* ***OR*** *'In an isolated system the total momentum before a collision (or explosion) is equal to the total momentum after the collision (or explosion)'.*

$$\Sigma p_{\text{before}} = \Sigma p_{\text{after}}$$

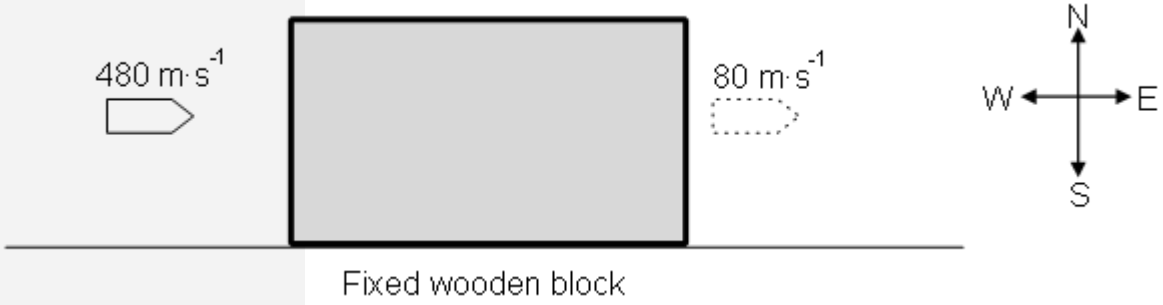
$$p_{\text{A(before)}} + p_{\text{B(before)}} = p_{\text{A(after)}} + p_{\text{B(after)}}$$

$$m_A v_{iA} + m_B v_{iB} + \ldots = m_A v_{fA} + m_B v_{fB} + \ldots$$

A bullet moves east at a velocity of 480 $m \cdot s^{-1}$. It hits a wooden block that is fixed to the floor. The bullet takes 0,01 s to move through the stationary block and emerges from the block at a velocity of 80 $m \cdot s^{-1}$ east. See the diagram below.

Ignore the effects of air resistance.

Consider the block-bullet system as an isolated system.



1.1 Explain what is meant by an isolated system as used in Physics. (2)

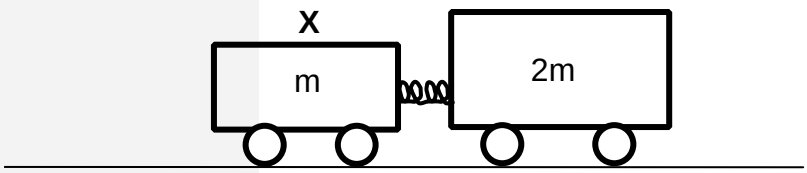
The magnitude of the momentum of the bullet before it enters the block is 24 kg·m·s-1.

1.2 Calculate the:

1.2.1 Mass of the bullet (3)

1.2.2 Average net force exerted by the wooden block on the bullet (5)

2. Two trolleys, X and Y, of masses m and 2m respectively, are held together by a compressed spring between them. Initially they are stationary on a horizontal floor, as shown below. Ignore the effects of friction.



The spring is now released and falls to the floor while the trolleys move apart.

The magnitude of the MOMENTUM of trolley X while it moves away is …

A zero.

B half the magnitude of the momentum of trolley Y.

C twice the magnitude of the momentum of trolley Y.

D the same as the magnitude of the momentum of trolley Y.

1.3 Two cars, P and Q, moving in a straight line, have the same momentum.

The kinetic energy of Q is greater than the kinetic energy of P.

Which ONE of the following statements regarding the cars is CORRECT?

A Q has a smaller mass than P.

B Q has the same mass as P.

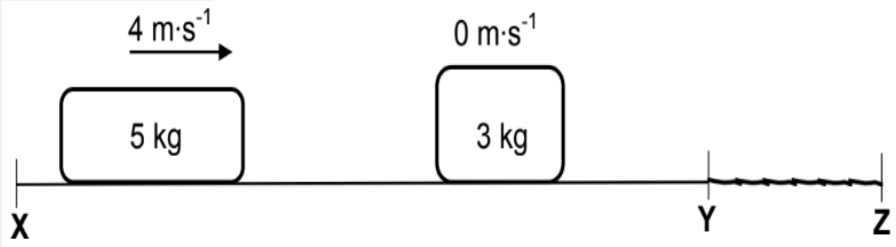
C Q is moving slower than P.

D Q is moving at the same speed as P.

1.4 The diagram below shows two sections, XY and YZ, of a horizontal, flat surface. Section XY is smooth, while section YZ is rough.

A 5 kg block, moving with a velocity of 4 $m \cdot s^{-1}$ 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, past point Y.

The combined blocks travel for 0,3 s from point Y before coming to a stop at point Z.



SESSION 2 | REACTION RATE

REVISION:

Question 5

i. Name the six factors that determine the rate of a chemical reaction.

ii. Name the two requirements according to the COLLISION THEORY for an effective collision between two molecules.

Grade 12 learners use the reaction between a sodium thiosulphate solution ($Na_2S_2O_3$) and a hydrochloric acid solution (HCl) to investigate the factors that affect reaction rates.

The balanced equation for this reaction is :

$$Na_2S_2O_3\,(aq) + 2\,HCl\,(aq) \rightarrow H_2O\,(l) + SO_2\,(g) + 2\,NaCl\,(aq) + S\,(s)$$

The time from the moment EQUAL VOLUMES of the two solutions are mixed untill the appearance of a certain amount of turbidity (sulphur precipitation) is taken as an indication of the reaction rate

Consider **INVESTIGATION A** (Experiment 1 to 3):

	Temp (°C)	[$Na_2S_2O_3$] ($mol.dm^{-3}$)	[HCl] ($mol.dm^{-3}$)	Time (s)
Experiment 1	20	0,5	0,5	40
Experiment 2	20	0,9	0,5	25
Experiment 3	20	1,4	0,5	15

iii. For **INVESTIGATION A**, name the:

a) Dependent variable
b) Independent variable

iv. What is the scientific conclusion that can be drawn from **INVESTIGATION A**?

Consider **INVESTIGATION B** (Experiment 4 to 6):

	Temp (°C)	[$Na_2S_2O_3$] ($mol.dm^{-3}$)	[HCl] ($mol.dm^{-3}$)	Time (s)
Experiment 4	20	0,5	0,5	40
Experiment 5	30	0,5	0,5	20
Experiment 6	50	0,5	0,5	10

SESSION 2 | REACTION RATE

REVISION:

v. In which one of the experiments (4 to 6) in **INVESTIGATION B** is the reaction rate the fastest? Give a reason for your answer.

vi. Explain your answer in question 6.4.1 in terms of the collision theory.

ANSWERS:

i. Catalyst, Temperature, Gas pressure, State of division (Reaction surface), Nature of the reagents, Concentration of solutes.

ii. Molecules will undergo effective collisions if :

- The orientation of the collisions is correct.
- The molecule has enough energy.

iii. INVESTIGATION **A**:

a) Reaction Rate / Time

b) Concentration of $Na_2S_2O_3$

iv. ANY ANSWER THAT DESCRIBES THE CORRECT RELATIONSHIP : ✓✓

The reaction rate increases with an increase in concentration of the $Na_2S_2O_3$

v. Experiment 6

- Highest temperature / Fastest time
- Average kinetic energy the highest.

vi. More particles have enough activation energy (Maxwell-Boltzmann curve).

More effective collisions per second

SESSION 2 | REACTION RATE

REVISION:

Question 6

i. Define the term: CATALYST

ii. Draw the following graphs to indicate the effect of a catalyst on each type of graph :

a) 3.2.1 Potential energy – ▲t graph

b) 3.2.2 Maxwell-Boltzmann curve

c) 3.2.3 Reaction Rate –▲t graph

iii. Name the catalyst used in each of the following reactions :

a) 3.3.1 Esterification

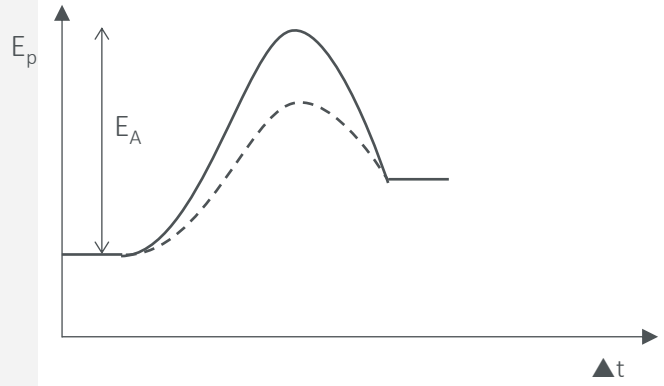
b) 3.3.2 Addition (Hydrogenation)

ANSWERS:

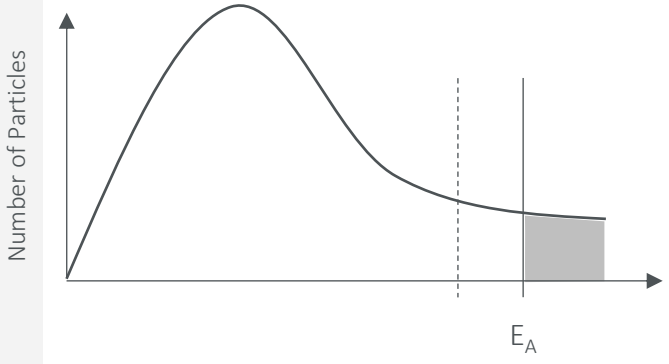
i. CATALYST: Chemical substance that lowers the potential energy of the activated complex and accelerates the reaction rate without participating in the reaction itself.

ii. GRAPHS

a)

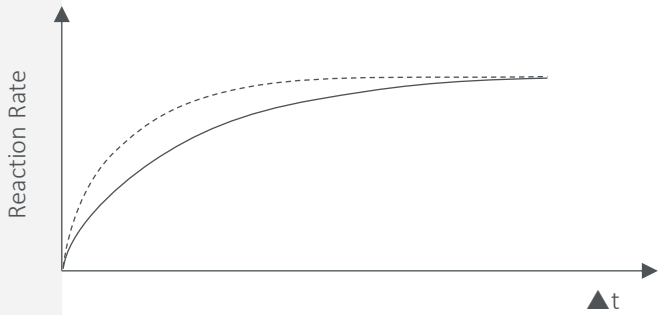


b)



ANSWERS:

c)



iii. Catalysts:

a) Sulfuric acid (H_2SO_4)

b) Platinum (Pt) / Nickel (Ni) / Palladium (Pd)

SESSION 2 | REACTION RATE

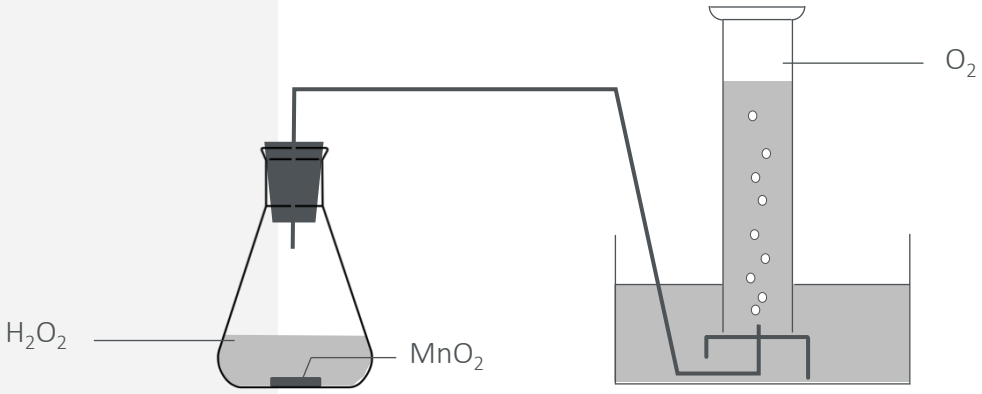
REVISION:

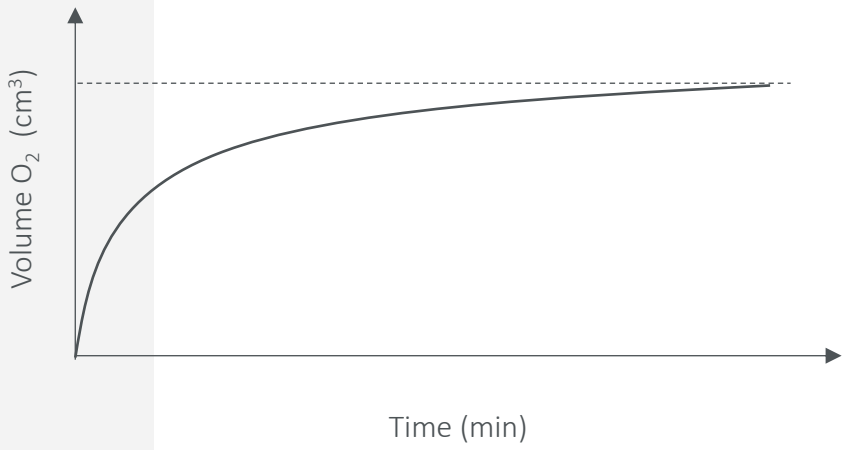
Question 7

Manganese dioxide (MnO_2) acts as a catalyst in the decomposition of hydrogen peroxide (H_2O_2) to form water and oxygen as products. The balanced equation is given :

$$2H_2O_2\,(aq) \rightarrow 2H_2O\,(l) + O_2\,(g)$$

One gram of MnO_2 powder was added to the hydrogen peroxide, with a concentration of 2 $mol.dm^{-3}$ at a temperature of 25°C and the volume of oxygen, which is collected by means of the downward displacement of water, was measured. The sketch below illustrates the experiment and the graph shows the rate at which the gas was collected in a gas cylinder.





SESSION 2 | REACTION RATE

REVISION:

i. Define the term: CATALYST

Copy the GRAPH of time versus volume O_2 onto your answer set. The experiment is repeated twice with a change to one of the constant variables. The first experiment therefore now serves as the control experiment.

ii. Draw the possible curves expected on the same axis system if:

a) No catalyst is used. (Name the new graph A)

b) The experiment is repeated at a higher temperature. (Name this new graph B)

iii. What mass of MnO_2 will be left at the end of the experiment?

iv. Define the term: REACTION RATE

v. Name two more factors, apart from the factors already used in this question, which will influence the rate of a chemical reaction.

vi. Refer to the collision theory to explain how the presence of a catalyst increases the rate of a reaction.

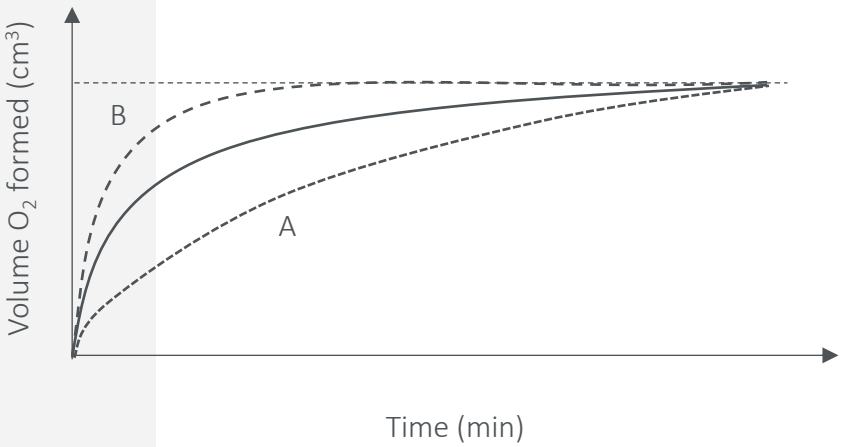
ANSWERS:

i. Chemical substance that lowers the potential energy of the activated complex and accelerates the reaction rate without participating in the reaction itself.

ii. GRAPHS

a) Start and End points same as original curve. Curve BELOW the original curve.

b) Start and End points same as original curve. Curve ABOVE the original curve.



ANSWERS:

iii. 1g MnO_2

iv. The change in concentration of reactants or products per unit time.

v. Concentration, Reaction surface (state of division), Nature of the reagents

vi. Catalyst lowers the activation energy.

More molecules possess enough energy for an effective collision.

More collisions occur in a shorter period of time.

Rate at which products are formed increases.

SESSION 2 | REACTION RATE

REVISION:

Question 8

i. Define the following terms:

a) Reaction rate

b) Activation energy

A Grade 12 learner uses the reaction of zinc with an excess of hydrochloric acid to investigate the factors that affect the rate of a chemical reaction. The balanced equation for the reaction is :

$$Zn\ (s) + 2HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2(g)$$

The learners carry out five experiments during the investigation and summarize all data in the following table. Reaction 1 is the CONTROL EXPERIMENT.

Experiments	Mass (Zn)	State of Division (Zn)	Concentration (HCl)	Temperature (HCl)
1	1g	Ppebbles	0,5 mol.dm^{-3}	25 °C
2	1g	Ppebbles	0,8 mol.dm^{-3}	25 °C
3	1g	Ppebbles	0,5 mol.dm^{-3}	35 °C
4	1g	Powder	0,5 mol.dm^{-3}	25 °C
5	2g	Ppebbles	0,5 mol.dm^{-3}	25 °C

ii. Calculate the average reaction rate (in mol.s^{-1}) of reaction 1 if the reaction takes two minutes to complete.

iii. Name the INDEPENDENT VARIABLE between the following reactions :

a) Experiment 1 and Experiment 2

b) Experiment 1 and Experiment 3

c) Experiment 1 and Experiment 4

d) Experiment 1 and Experiment 5

ANSWERS:

i. DEFINITIONS:

a) The change in concentration of reactants or products per unit time.

b) The minimum energy required for a reaction to occur.

ii. $n(Zn) = m \div M = 1 \div 65 = 0,015$ mol

Average Reaction Rate= $\blacktriangle n \div \blacktriangle t = 0,015 \div 120$

Average Reaction Rate = $1,28 \times 10^{-4}$ $mol.s^{-1}$

(Answer if rounded values were used : $1,25 \times 10^{-4}$ $mol.s^{-1}$)

iii. VARIABLES:

a) Concentration of the acid

b) Temperature of the reaction mixture

c) State of division of the zinc

d) NONE! (Mass of the reagent is not a factor)

SESSION 3 | ELECTRIC CIRCUITS

Ohm's Law

Write down Ohm's law in words: The potential difference over a conductor is directly proportional to the current in the conductor at constant temperature.

Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.

Name the difference between ohmic conductors and non-ohmic conductors and give an example of each.

Solve problems using $R = \frac{V}{I}$ for series and parallel circuits (maximum four resistors).

Power, energy (Grade 11)

Define power as the rate at which work is done.

Solving problems using $P = \frac{W}{\triangle t}$

Solving problems using $P = VI$, $P = I^2R$ or $P = \frac{V^2}{R}$

Solve circuit problems that include the concepts of power and electrical energy.

Conclude that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.

Calculate the cost of electricity consumption if the power specifications of the devices, the duration and the cost of 1 kWh are given.

Internal resistance, series and parallel networks

Solving problems involving current, potential difference and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors, excluding internal resistance).

Define the term emf as the maximum energy a battery produces per unit charge flowing through it.

Solving problems using $\varepsilon = V_{las} + V_{interne\ weerstand}$ or $\varepsilon = IR_{eks} + Ir$.

Solve circuit problems, with internal resistance, involving series parallel networks of resistors (maximum four resistors).

FORMULAE

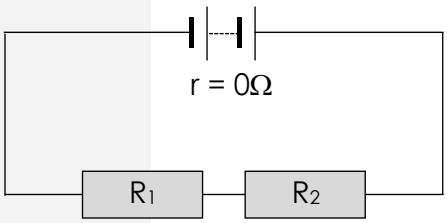
$R = \frac{V}{I}$	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
$\text{emk } (\varepsilon) = I(R + r)$	$R_S = R_1 + R_2 + \cdots$
$W = VQ$	$P = \frac{W}{\Delta t}$
$W = VI\Delta t$	$P = VI$
$W = I^2R\Delta t$	$P = I^2R$
$W = \frac{V^2\Delta t}{R}$	$P = \frac{V^2}{R}$

1.1 PRE-TEST

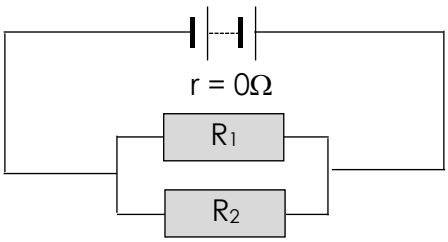
QUESTION 1 (MULTIPLE-CHOICE)

Four options are given as possible answers to the following questions. Each question has only ONE correct answer. Select the answer and write only the letter (A–D) next to the question number (1.1–1.5), for example, 1.6 D.

1.1 Two identical resistors are connected first in series (circuit A), and then in parallel (circuit B). The same battery with negligible resistor is used in both circuits. The power in R_1 in circuit A is **P**. (2)



Circuit A

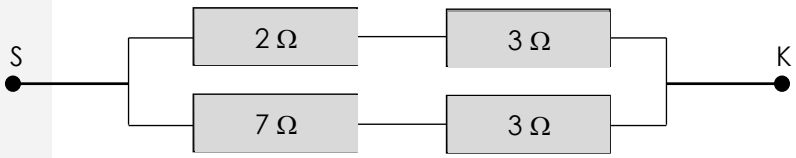


Circuit B

What is the power in R_1 in circuit B?

A. ¼ P
B. ½ P
C. 2 P
D. 4 P

1.2 Consider the following combination of resistors that are part of a larger circuit. A potential difference of V is applied over points S and K. (2)



Which ONE of the following gives the current through the 7Ω resistor?

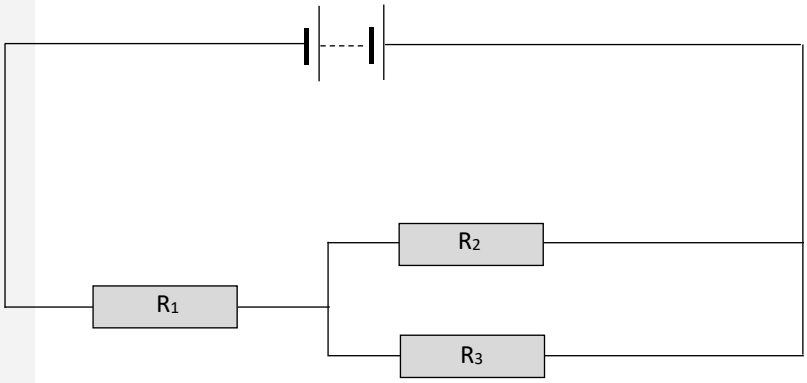
A. $\frac{1}{3}$ V

B. $\frac{1}{5}$ V

C. $\frac{1}{7}$ V

D. $\frac{1}{10}$ V

1.3 Three IDENTICAL resistors are connected in a circuit as follows:



What is the power delivered by R_2 if the power is delivered by R_1 is **P**?

A. 2**P**
B. 4**P**
C. ½**P**
D. ¼**P**

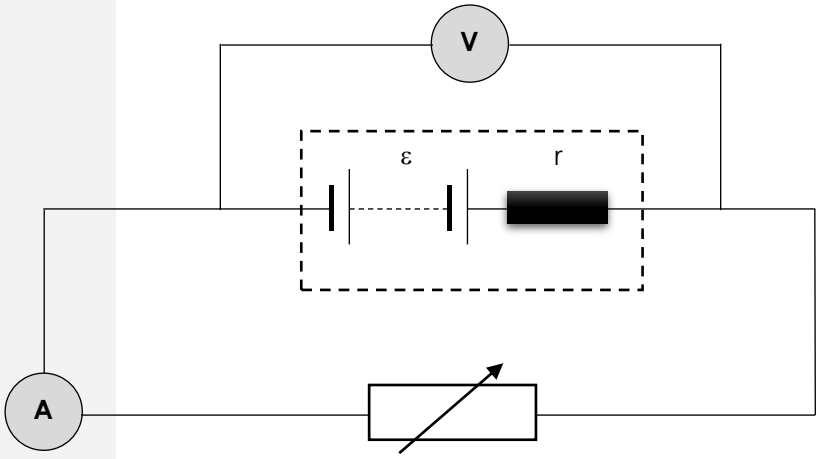
1.4 The reading on a voltmeter connected OVER a battery in a circuit shows a reading of 6 V if the switch is open and no current flows into the external circuit, and 5.8 V if the switch is closed.

The difference between the two readings is known as:

A. The emf of the battery.
B. The internal resistance of the battery.
C. The potential difference of the battery.
D. The lost volts of the battery.

QUESTION 2

During a practical investigation, the Grade 12 Physical Science learners set up the following circuit to investigate the relationship between the potential difference and the current through a battery.



Two of the readings obtained during the investigation are shown in the following table:

Reading no.:	Current (A)	PV (V)
1.		
2.	0,3	2,52
3.	1,6	0,71
4.		

2.1 State Ohm's Law into words. (2)

2.2 Name the following variables for this investigation:

2.2.1 Independent variable (1)

2.2.2 Dependent variable (1)

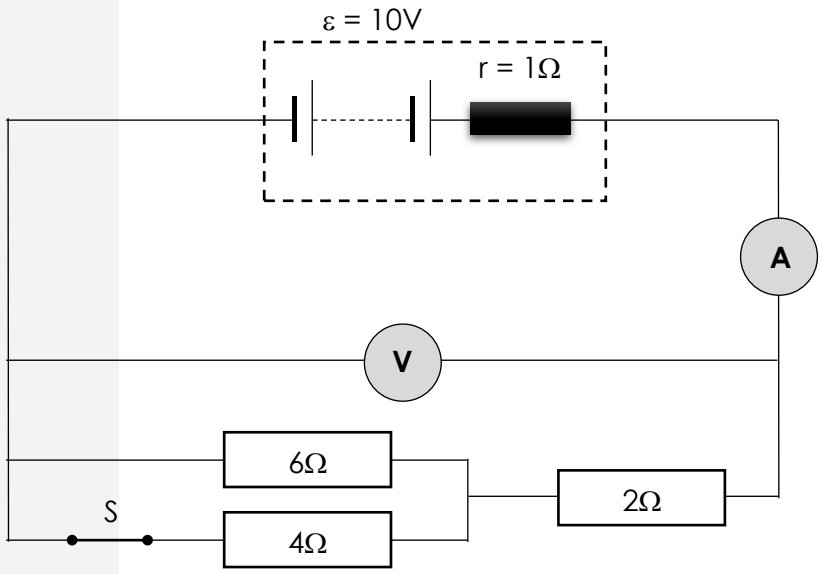
2.3 Calculate:

2.3.1 The internal resistance (r) of the battery. (5)
[HINT: Determine two equations with two unknowns]

2.3.2 The emf of the battery. (3)

QUESTION 3

A battery with an emf of 10V and an internal resistance of 1Ω is connected to three external resistors as shown in the following circuit diagram:



3.1 Calculate (with switch S closed):

3.1.1 The reading on the ammeter. (5)

3.1.2 The reading on the voltmeter. (2)

3.2 How will the reading on the voltmeter change if switch S is opened? (2)
(Only write INCREASE, DECREASE or STAY THE SAME)

3.3 Explain your answer in QUESTION 3.2 without showing any calculation. (1)

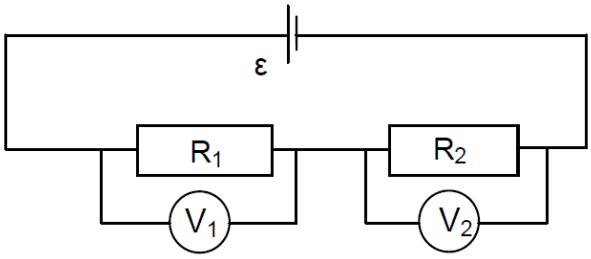
[10]

POST-TEST

QUESTION 4 (MULTIPLE-CHOICE)

Four options are given as possible answers to the following questions. Each question has only ONE correct answer. Select the answer and write only the letter (A–D) next to the question number (8.1– 8.5), for example, 8.6 D.

4.1 The diagram below shows a cell with emf (ε), and two resistors, R_1 and R_2, in series, with $R_1 < R_2$. The cell has negligible internal resistance and the voltmeters have a very high resistance. (2)



Which ONE of the following is CORRECT?

A. $V_1 = V_2 = \varepsilon$

B. $V_1 > V_2$

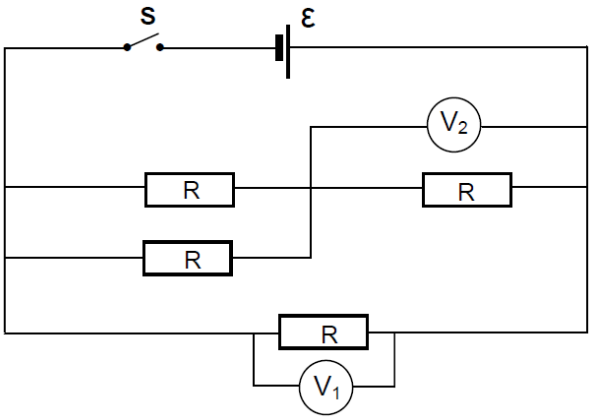
C. $\frac{V_1}{R_1} = \frac{V_2}{R_2}$

D. $\frac{V_1^2}{R_1} > \frac{V_2^2}{R_2}$

4.2 Which one of the following phrases describes the emf of a battery? (2)

A. Energy supplied per unit time
B. Maximum energy supplied per unit load
C. Current supplied per unit load
D. Charge transferred per unit time

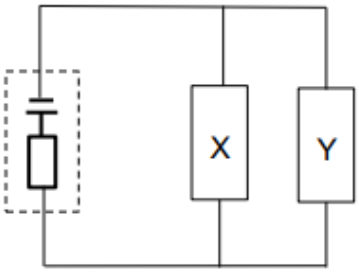
4.3 In the circuit diagram below, all the resistances are IDENTICAL. Ignore the internal resistance of the cell and the resistance of the connecting wires. (2)



When switch **S** is CLOSED, the reading on voltmeter V_1 is 6 V.
What will the reading be on voltmeter V_2?

A. 2V
B. 3V
C. 4V
D. 6V

4.4 In the circuit below, the resistance of Y is twice that of X. (2)



What is the magnitude of the power consumed by Y, if the power consumed by X is equal to **P**?

A. ¼P
B. 2P
C. ½P
D. 4P