education
Department of
Education
FREE STATE PROVINCE

PHYSICAL SCIENCES
EXAMINABLE CONTENT
GRADE 12
CAPS
2020 onwards

To all grade 12 physical sciences learners:

1. **Each learner must be in possession of this document.**
2. **Use this document to ensure that all the content is covered in class.**
3. **Read this document on a daily basis to acquaint yourself with what is expected. Use a pencil/pen to tick off as aspects are completed in class.**
4. **You must complete a minimum of 5 examination type questions on each topic in your homework book. Ensure that these tasks are present in your homework book and that you do corrections of mistakes made. To help you to control that you do enough homework, the content is divided into topics.**
5. **Make sure that you know all definitions described in this document. Most of the definitions are printed in bold so that it is easier to recognise them.**
6. **When preparing for a test or an examination, ensure that you study all concepts, described in this document, applicable to a specific test/examination.**
7. **Make sure that you revise the grade 11 content that is also examinable in grade 12. Use previous question papers to practice questions asked about these topics.**

This document consists of 53 pages.

Minimum number of formal and informal assessment tasks for this year

Grade 12			
Term	**Month**	**Formal Assessment Tasks**	**Informal Assessment Tasks**
1	February	Practical Task 1	Homework/Classwork: 31 Experiments: 1 Informal tests: 5
	March	Control Test 1	
2	May	Practical Task 2	Homework/Classwork: 26 Experiments: 2 Informal tests: 4
	June	June Examination	
3	July	Practical Task 3	Homework/Classwork: 25 Experiments: 1 Informal tests: 6
	September	September Examination	
4	November	November Examination	

What must I prepare for each control test / examination?

Refer to **Appendix D** at the end of this document.

What is the format of the question papers?

Control Tests			
	Grade 10	**Grade 11**	**Grade 12**
Multiple-choice questions	7 x 2 each = 14 marks	10 x 2 each = 20 marks	10 x 2 each = 20 marks
Structured questions	61 marks	80 marks	80 marks
Duration	1,5 hours	2 hours	2 hours
Total of paper	**75 marks**	**100 marks**	**100 marks**

Examinations	
	All grades (10–12)
Multiple-choice questions	10 x 2 each = 20 marks
Structured questions	130 marks
Duration	3 hours
Total of paper	**150 marks**

What is the weighting of cognitive levels in control tests and examinations?

	Percentage of marks per paper allocated to each level			
Control test/examination	**Level 1**	**Level 2**	**Level 3**	**Level 4**
March control tests (10–12)	15%	35%	40%	10%
June examination (10 & 11) One paper each	15%	35%	40%	10%
June, September & November examination (12 P1)	15%	35%	40%	10%
June, September & November examination (12 P2)	15%	40%	35%	10%
September control tests (10 & 11)	15%	35%	40%	10%
November examination (10P1 & 11P1)	15%	35%	40%	10%
November examination (10P2 & 11P2)	15%	40%	35%	10%

Skills in Physical Sciences

- **Identify and question phenomena:**
  - Formulate an investigative question.
  - List all possible variables.
  - Formulate a testable hypothesis.
- **Design/Plan of an investigation:**
  - Identify variables (dependent, independent and controlled variables).
  - List appropriate apparatus.
  - Plan the sequence of steps which should include, amongst others:
    - The need for more than one trial to minimise experimental errors.
    - Identify safety precautions that need to be taken.
    - Identify conditions that ensure a fair test.
    - Set an appropriate control.
- **Graphs:**
  - Draw accurate graphs from given data/information.
  - Interpret graphs.
  - Draw sketch graphs from given information.
- **Results:**
  - Identify patterns/relationships in data.
  - Interpret results.
- **Conclusions:**
  - Draw conclusions from given information, e.g. tables, graphs.
  - Evaluate the validity of conclusions.
- **Calculations:**
  - Solve problems using two or more different calculations (multistep calculations).
- **Descriptions:**
  - Explain/Describe/Argue the validity of a statement/event using scientific principles.

FIRST TERM

Topic 2: Newton's laws and application of Newton's laws (Grade 11)

Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)

- Define ***normal force*, N**, as **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.**
- Define ***frictional force*, f,** as **the force that opposes the motion of an object and which acts parallel to the surface.**
  Define ***static frictional force*, f_s**, as **the force that opposes the tendency of motion of a stationary object relative to a surface and acts parallel to the surface.**
  Define ***kinetic frictional force*, f_k**, as **the force that opposes the motion of a moving object relative to a surface and acts parallel to the surface.**
  Know that a frictional force:
  - Is proportional to the normal force
  - Is independent of the area of contact
  - Is independent of the velocity of motion
- Solve problems using $f_s^{max} = \mu_s N$ where f_s^{max} is the maximum static frictional force and μ_s is the coefficient of static friction.
  NOTE:
  - If a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.
  - The static frictional force is a maximum (f_s^{max}) just before the object starts to move across the surface.
  - If the applied force exceeds f_s^{max}, a resultant (net) force accelerates the object.
- Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.

Force diagrams, free-body diagrams

- Draw force diagrams.
- Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings)
- Resolve a two-dimensional force (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.
- Determine the resultant/net force of two or more forces.

Newton's first, second and third laws of motion

- State **Newton's first law of motion**: **A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.**
- Discuss why it is important to wear seatbelts using Newton's first law of motion.
- State **Newton's second law of motion**: **When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.**
- Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.

- Apply Newton's laws of motion to a variety of equilibrium and non-equilibrium problems including: (See appendix A for examples of the following scenarios.)
  - A single object:
    - Moving on a horizontal plane with or without friction
    - Moving on an inclined plane with or without friction
    - Moving in the vertical plane (lifts, rockets, etc.)
  - Two-body systems (joined by a light inextensible string):
    - Both on a flat horizontal plane with or without friction
    - One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley
    - Both on an inclined plane with or without friction
    - Both hanging vertically from a string over a frictionless pulley
- State **Newton's third law of motion**: **When object A exerts a force on object B, object B SIMULTANEOUSLY exerts an oppositely directed force of equal magnitude on object A.**
- Identify action-reaction pairs.
- List the properties of action-reaction pairs.

Newton's Law of Universal Gravitation

- State **Newton's Law of Universal Gravitation**: **Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.**
- Solve problems using $F = \frac{Gm_1m_2}{r^2}$.
- Calculate acceleration due to gravity on a planet using $g = \frac{Gm}{r^2}$.
- Describe ***weight*** as **the gravitational force, in newton (N), exerted on an object**. Describe **mass** as the **amount of matter in a body measured in kilogram (kg)**.
- Calculate weight using the expression w = mg.
- Calculate the weight of an object on other planets with different values of gravitational acceleration.
- Explain ***weightlessness*** as **the sensation experienced when all contact forces are removed i.e. no external objects touch one's body.** For example, when in free fall, the only force acting on your body is the force of gravity that is a non-contact force. Since the force of gravity cannot be felt without any other opposing forces, you would have no sensation of it and you would feel weightless when in free fall.

Topic 1: Momentum and Impulse (Grade 12)

Momentum

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

Newton's second law of motion in terms of momentum

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

Impulse

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

Conservation of momentum and elastic and inelastic collisions

- Explain what is meant by *a* ***closed system*** **(in Physics), i.e. a system on which the resultant (or net) external force is zero.**
  A closed 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 a closed system remains constant (is conserved).**
- Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.
- Distinguish between *elastic collisions* and *inelastic collisions* by calculation.

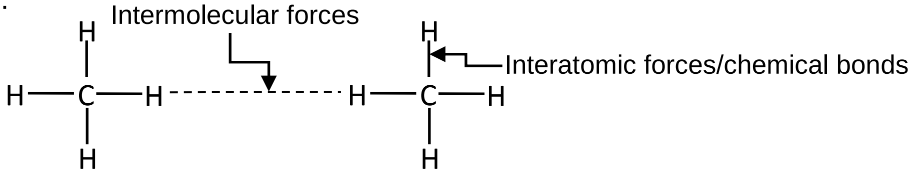
Topic 2: Vertical Projectile Motion in One Dimension (1D) (Grade 12)

- Explain what is meant by a *projectile*, i.e. an object which has been given an initial velocity and on which the only force acting is the gravitational force/weight.
- Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.
- Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:
  - A free-falling object
  - An object thrown vertically upwards
  - An object thrown vertically downwards
  - Bouncing objects (restricted to balls)
- For a given x vs. t, v vs. t or a vs. t graph, determine:
  - Position
  - Displacement
  - Velocity or acceleration at any time t
- For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:
  - Bouncing
  - Thrown vertically upwards
  - Thrown vertically downward

Topic 4: Intermolecular Forces (Grade 11)

Intermolecular forces and interatomic forces (chemical bonds)

- Name and explain the different intermolecular forces (Van der Waal's forces):
  - (i) **Dipole-dipole forces**:
    Forces between two polar molecules
  - (ii) **Induced dipole forces or London forces:**
    Forces between non-polar molecules
  - (iii) **Hydrogen bonding:**
    Forces between molecules in which hydrogen is covalently bonded to nitrogen, oxygen or fluorine – a special case of dipole-dipole forces
- Describe the difference between *intermolecular forces* and *interatomic forces* (intramolecular forces) using a diagram of a group of small molecules; and in words.
  Example:



- State the relationship between intermolecular forces and molecular size. For non-polar molecules, the strength of induced dipole forces increases with molecular size.
- Explain the effect of intermolecular forces on boiling point, melting point and vapour pressure.
  Boiling point:
  The temperature at which the vapour pressure of a substance equals atmospheric pressure. The stronger the intermolecular forces, the higher the boiling point.
  Melting point:
  The temperature at which the solid and liquid phases of a substance are at equilibrium. The stronger the intermolecular forces, the higher the melting point.
  Vapour pressure:
  The pressure exerted by a vapour at equilibrium with its liquid in a closed system. The stronger the intermolecular forces, the lower the vapour pressure.

Topic 3: Organic Molecules (Grade 12)

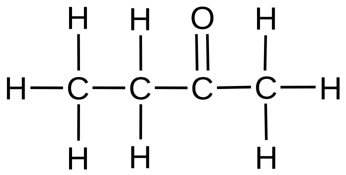
- Define ***organic molecules*** **as molecules containing carbon atoms**.

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

- Write down condensed structural formulae, structural formulae and molecular formulae (up to 8 carbon atoms, one functional group per molecule) for:
  - Alkanes (no ring structures)
  - Alkenes (no ring structures)
  - Alkynes
  - Halo-alkanes (primary, secondary and tertiary haloalkanes; no ring structures)
  - Alcohols (primary, secondary and tertiary alcohols)
  - Carboxylic acids
  - Esters
  - Aldehydes
  - Ketones
- Know the following definitions/terms:
  Molecular formula: A chemical formula that indicates the type of atoms and the correct number of each in a molecule.
  Example: C_4H_8O

Structural formula: A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.

Example:

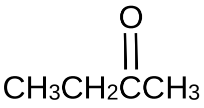


$$\begin{array}{ccccccccc} & & H & & H & & O & & H \\ & & | & & | & & \| & & | \\ H & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & & & | \\ & & H & & H & & & & H \end{array}$$

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

Example:

$CH_3CH_2COCH_3$ OR



$$CH_3CH_2\overset{\overset{\large O}{\|}}{C}CH_3$$

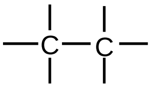
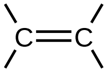
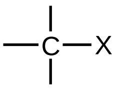
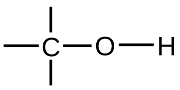
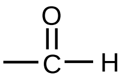
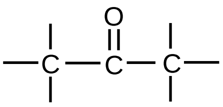
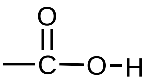
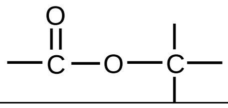
Hydrocarbon: Organic compounds that consist of hydrogen and carbon only.

Homologous series: A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a CH_2 group.

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

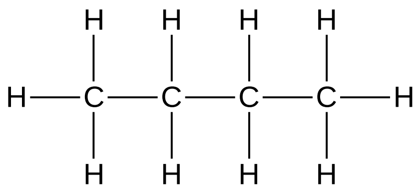
Unsaturated compounds: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains.

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

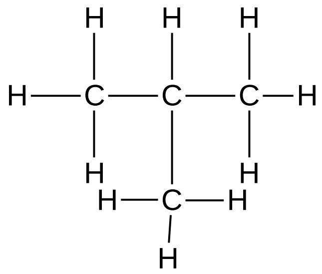
Homologous series	**Structure of functional group**	
	Structure	**Name/Description**
Alkanes		Only C-H and C-C single bonds
Alkenes		Carbon-carbon double bond
Alkynes	$-C\equiv C-$	Carbon-carbon triple bond
Haloalkanes	 (X = F, Cℓ, Br, I)	Halogen atom bonded to a saturated C atom
Alcohols		Hydroxyl group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

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

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

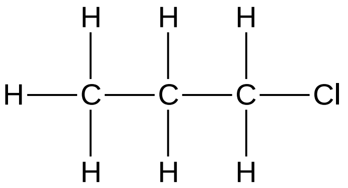


Butane

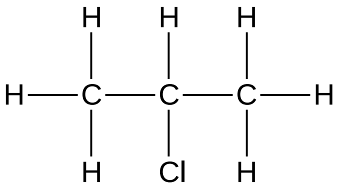


2-methylpropane

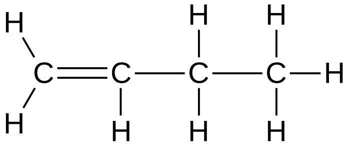
  - **Positional isomers: Same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain**, e.g. 1-choropropane and 2-chloropropane or but-2-ene and but-1-ene



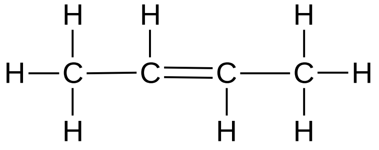
1-chloropropane



2-choropropane

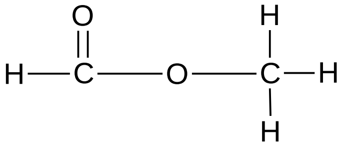


but-1-ene

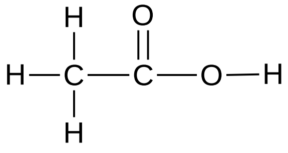


but-2-ene

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



methyl methanoate



ethanoic acid

IUPAC naming and formulae

- Write down the IUPAC name when given the structural formula or condensed structural formula for compounds from the homologous series above, restricted to one functional group per compound, except for haloalkanes. For haloalkanes, maximum two functional groups per molecule.
- Write down the structural formula when given the IUPAC name for the above homologous series.
- Identify alkyl substituents (methyl- and ethyl-) in a chain to a maximum of THREE alkyl substituents on the parent chain.

- When naming haloalkanes, the halogen atoms do not get preference over alkyl groups – numbering should start from the end nearest to the first substituent, either the alkyl group or the halogen. In haloalkanes, where e.g. a Br and a Cℓ have the same number when numbered from different ends of chain, Br gets alphabetical preference.
- When writing IUPAC names, substituents appear as prefixes written alphabetically (bromo, chloro, ethyl, methyl), ignoring the prefixes di- and tri.

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

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

Oxidation of alkanes

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

Esterification

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

Substitution, addition and elimination reactions: See appendix B
NB: This part must be studied in conjunction with Appendix B

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

Plastics and polymers (ONLY BASIC POLYMERISATION as application of organic chemistry)

- Describe the following terms:
  Macromolecule: A molecule that consists of a large number of atoms
  Polymer: A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern
  Monomer: Small organic molecules that can be covalently bonded to each other in a repeating pattern
  Polymerisation: A chemical reaction in which monomer molecules join to form a polymer
- Distinguish between *addition polymerisation* and *condensation polymerisation*:
  Addition polymerisation: A reaction in which small molecules join to form very large molecules by adding on double bonds
  Addition polymer: A polymer formed when monomers (usually containing a double bond) combine through an addition reaction
  Condensation polymerisation: Molecules of two monomers with different functional groups undergo condensation reactions with the loss of small molecules, usually water
  Condensation polymer: A polymer formed by two monomers with different functional groups that are linked together in a condensation reaction in which a small molecule, usually water, is lost
- Identify monomers from given addition polymers.
- Write down an equation for the polymerisation of ethene to produce polythene.
- State the industrial uses of polythene.

SECOND TERM

Topic 4: Work, Energy and Power (Grade 12)

Work

- Define the **work done** on an object by a constant force F as **$F\Delta x\cos\theta$, where F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement.** (Work is done by a force on an object – the use of 'work is done against a force', e.g. work done against friction, should be avoided.)
- Draw a force diagram and free-body diagrams.
- Calculate the net/total work done on an object.
- Distinguish between *positive net/total work done* and *negative net/total work done* on the system.

Work-energy theorem

- State the **work-energy theorem**: **The net (or total) work done on an object is equal to the change in the object's kinetic energy** OR the work done on an object by a resultant (or net) force is equal to the change in the object's kinetic energy.
  In symbols: $W_{net} = \Delta K = K_f - K_i$.
- Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).

Conservation of energy with non-conservative forces present

- Define a ***conservative forc****e* as **a force for which the work done in moving an object between two points is independent of the path taken**. Examples are gravitational force, the elastic force in a spring and electrostatic forces (coulomb forces).
- Define a ***non-conservative force*** as **a force for which the work done in moving an object between two points depends on the path taken**. Examples are frictional force, air resistance, tension in a chord, etc.
- State the **principle of conservation of mechanical energy**: **The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant.** (A system is isolated when the resultant/net external force acting on the system is zero.)
- Solve conservation of energy problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$
- Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.

Power

- Define ***power*** as the **rate at which work is done or energy is expended**.
  In symbols: $P = \frac{W}{\Delta t}$
- Calculate the power involved when work is done.
- Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

Topic 5: Doppler Effect (relative motion between source and observer) (Grade 12)

With sound and ultrasound

- State the **Doppler effect as the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.**
- Explain (using appropriate illustrations) the change in pitch observed when a source moves toward or away from a listener.
- Solve problems using the equation $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ when EITHER the source or the listener is moving.
- State applications of the Doppler effect.

With light – red shifts in the universe (evidence for the expanding universe)

- Explain *red shifts* and *blue shifts* using the Doppler Effect.
- Use the Doppler effect to explain why we conclude that the universe is expanding.

Topic 13: Representing Chemical Change (Grade 10)

Balanced chemical equations

- Write and balance chemical equations.
- Interpret balanced reaction equations in terms of:
  - Conservation of atoms
  - Conservation of mass (use relative atomic masses)

Topic 8: Quantitative Aspects of Chemical Change (Grade 11)

Molar volume of gases

- 1 mole of any gas occupies 22,4 dm^3 at 0 °C (273 K) and 1 atmosphere (101,3 kPa).

Volume relationships in gaseous reactions

- Interpret balanced equations in terms of volume relationships for gases, i.e. under the same conditions of temperature and pressure, equal number of moles of all gases occupy the same volume.

Concentration of solutions

- Calculate the molar concentration of a solution.

More complex stoichiometric calculations

- Determine the empirical formula and molecular formula of compounds.
- Determine the percentage yield of a chemical reaction.
- Determine percentage purity or percentage composition, e.g. the percentage $CaCO_3$ in an impure sample of seashells.
- Perform stoichiometric calculations based on balanced equations.
- Perform stoichiometric calculations based on balanced equations that may include limiting reagents.

Topic 12: Energy and Change (Grade 11)

Energy changes in reactions related to bond energy changes

- Define *heat of reaction* (ΔH) as the energy absorbed or released in a chemical reaction.
- Define ***exothermic reactions*** as **reactions that release energy**.
- Define ***endothermic reactions*** as **reactions that absorb energy**.
- Classify (with reason) reactions as exothermic or endothermic.

Exothermic and endothermic reactions

- **State that $\Delta H > 0$ for endothermic reactions, i.e. reactions in which energy is absorbed.**
- **State that $\Delta H < 0$ for exothermic reactions, i.e. reactions in which energy is released.**

Activation energy

- Define ***activation energy*** as **the minimum energy needed for a reaction to take place**.
- Define an ***activated complex*** as **the unstable transition state from reactants to products**.
- Draw or interpret fully labelled sketch graphs (potential energy versus course of reaction graphs) of catalysed and uncatalysed endothermic and exothermic reactions.

Topic 6: Rate and Extent of Reaction (Grade 12)

Rates of reaction and factors affecting rate

- Define ***reaction rate*** as the **change in concentration of reactants or products per unit time**.
- Calculate reaction rate from given data.

  Rate = $\frac{\Delta c}{\Delta t}$ (Unit: $mol \cdot dm^{-3} \cdot s^{-1}$)

  Questions may also include calculations of rate in terms of change in mass/volume/ number of moles per time.
- List the factors that affect the rate of chemical reactions, i.e. nature of reacting substances, surface area, concentration (pressure for gases), temperature and the presence of a catalyst.
- Explain in terms of the collision theory how the various factors affect the rate of chemical reactions. The collision theory is a model that explains reaction rate as the result of particles colliding with a certain minimum energy.

Measuring rates of reaction

- Answer questions and interpret data (tables or graphs) on different experimental techniques for measuring the rate of a given reaction.

Mechanism of reaction and of catalysis

- Define the term *positive* ***catalyst*** as a **substance that increases the rate of a chemical reaction without itself undergoing a permanent change.**
- Interpret graphs of distribution of molecular energies (number of particles against their kinetic energy or Maxwell-Boltzmann curves) to explain how a catalyst, temperature and concentration affect rate.
- Explain that a catalyst increases the rate of a reaction by providing an alternative path of lower activation energy. It therefore decreases the net/total activation energy.

Topic 7: Chemical Equilibrium (Grade 12)

Chemical equilibrium and factors affecting equilibrium

- Explain what is meant by:
    - **Open system: A system which continuously interacts with the environment – it exchanges matter and energy with its environment.**

      Closed system: A system that only exchanges energy with its surroundings, but it does not exchange matter with its surroundings.

      (An *isolated system* does not exchange matter or energy with its surroundings.)
    - **A reversible reaction: A reaction is reversible when products can be converted back to reactants.**
    - **Chemical equilibrium: It is a dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.**
- List the factors that influence the position of an equilibrium, i.e. pressure (gases only), concentration and temperature.

Equilibrium constant

- List the factors that influence the value of the equilibrium constant, K_c.
- Write down an expression for the equilibrium constant having been given the equation for the reaction.
- Perform calculations based on K_c values.
- Explain the significance of high and low values of the equilibrium constant.

Application of equilibrium principles

- State **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.**
- Use Le Chatelier's principle to explain changes in equilibria qualitatively.
- Interpret graphs of equilibrium, e.g. concentration/rate/number of moles/mass/ volume versus time graphs.
- Explain the use of rate and equilibrium principles in the Haber process and the contact process.

Topic 8: Acids and Bases (Grade 12)

Acid-base reactions

- Define *acids* and *bases* according to Arrhenius and Lowry-Brønsted:

  Arrhenius theory: An acid is a substance that produces hydrogen ions (H^+)/hydronium ions (H_3O^+) when it dissolves in water. A base is a substance that produces hydroxide ions (OH^-) when it dissolves in water.

  Lowry-Brønsted theory: An acid is a proton (H^+ ion) donor. A base is a proton (H^+ ion) acceptor.
- Distinguish between *strong acids/bases* and *weak acids/bases* with examples.

  Strong acids ionise completely in water to form a high concentration of H_3O^+ ions. Examples of strong acids are hydrochloric acid, sulphuric acid and nitric acid.

  Weak acids ionise incompletely in water to form a low concentration of H_3O^+ ions. Examples of weak acids are ethanoic acid and oxalic acid.

  Strong bases dissociate completely in water to form a high concentration of OH^- ions. Examples of strong bases are sodium hydroxide and potassium hydroxide.

  Weak bases dissociate/ionise incompletely in water to form a low concentration of OH^- ions. Examples of weak bases are ammonia, calcium carbonate, potassium carbonate, calcium carbonate and sodium hydrogen carbonate.

- Distinguish between *concentrated acids/bases* and *dilute acids/bases*.
  Concentrated acids/bases contain a large amount (number of moles) of acid/base in proportion to the volume of water.
- **Dilute acids/bases contain a small amount (number of moles) of acid/base in proportion to the volume of water.**
- Write down the reaction equations of aqueous solutions of acids and bases.
  Examples: $HC\ell(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + C\ell^-(aq)$ (HCℓ is a monoprotic acid.)
  $NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$
  $H_2SO_4(aq) + 2H_2O(\ell) \rightarrow 2H_3O^+(aq) + SO_4^{2-}(aq)$ (H_2SO_4 is a diprotic acid.)
- Identify conjugate acid-base pairs for given compounds. When the acid, HA, loses a proton, its conjugate base, A^-, is formed. When the base, A^-, accepts a proton, its conjugate acid, HA, is formed. These two are a conjugate acid-base pair.
- **Describe a substance that can act as either acid or base as amphiprotic or as an ampholyte**. Water is a good example of an ampholyte. Write equations to show how an amphiprotic substance can act as acid or base.
- Write down neutralisation reactions of common laboratory acids and bases.
  Examples: $HC\ell(aq) + NaOH(aq)/KOH(aq) \rightarrow NaC\ell(aq)/KC\ell(aq) + H_2O(\ell)$
  $HC\ell(aq) + Na_2CO_3(aq) \rightarrow NaC\ell(aq) + H_2O(\ell) + CO_2(g)$
  $HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(\ell)$
  $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$
  $(COOH)_2(aq) + NaOH(aq) \rightarrow (COO)_2Na_2(aq) + H_2O(\ell)$
  $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$
  NOTE: The above are examples of equations that candidates should be able to write from given information. However, any other neutralisation reaction can be given in the question paper to assess, e.g., stoichiometry calculations.
- Determine the approximate pH (equal to, smaller than or larger than 7) of salts in salt hydrolysis. **Define *hydrolysis* as the reaction of a salt with water.**
  - Hydrolysis of the salt of a weak acid and a strong base results in an alkaline solution, i.e. the pH > 7. Examples of such salts are sodium ethanoate, sodium oxalate and sodium carbonate.
  - Hydrolysis of the salt of a strong acid and a weak base results in an acidic solution, i.e. the pH < 7. An example of such a salt is ammonium chloride.
  - The salt of a strong acid and a strong bases does not undergo hydrolysis and the solution of the salt will be neutral, i.e. pH = 7.
- Motivate the choice of a specific indicator in a titration. Choose from methyl orange, phenolphthalein and bromothymol blue. Define the ***equivalence point* of a titration** as **the point at which the acid /base has completely reacted with the base/acid.**
  Define the *endpoint* of a titration as the point where the indicator changes colour.
- Perform stoichiometric calculations based on titrations of a strong acid with a strong base, a strong acid with a weak base and a weak acid with a strong base. Calculations may include percentage purity.
- For a titration, e.g. the titration of oxalic acid with sodium hydroxide:
  - List the apparatus needed or identify the apparatus from a diagram.
  - Describe the procedure to prepare a standard oxalic acid solution.
  - Describe the procedure to conduct the titration.
  - Describe safety precautions.
  - Describe measures that need to be in place to ensure reliable results.
  - Interpret given results to determine the unknown concentration.
- Explain the **pH scale** as a scale of **numbers from 0 to 14 used to express the acidity or alkalinity of a solution.**
- Calculate pH values of strong acids and strong bases using $pH = -\log[H_3O^+]$.
- Define K_w as the equilibrium constant for the ionisation of water or the ionic product of water or the ionisation constant of water, i.e. $K_w = [H_3O^+][OH^-] = 1 \times 10^{14}$ by 298 K.

- Explain the *auto-ionisation of water*, i.e. the reaction of water with itself to form H_3O^+ ions and OH^- ions.
- Interpret K_a values of acids to determine the relative strength of given acids. Interpret K_b values of bases to determine the relative strength of given bases.
- Compare strong and weak acids by looking at:
  - pH (monoprotic and diprotic acids)
  - Conductivity
  - Reaction rate

Topic 9: Electrostatics (Grade 11)

Coulomb's law

- State **Coulomb's law**: **The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r)between them:**
- Solve problems using the equation $F = \frac{kQ_1Q_2}{r^2}$ for charges in one dimension (1D) (restrict to three charges).
- Solve problems using the equation $F = \frac{kQ_1Q_2}{r^2}$ for charges in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right- angled triangle').

Electric field

- Describe an *electric field* as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
- Draw electric field patterns for the following configurations:
  - A single point charge
  - Two point charges (one negative, one positive OR both positive OR both negative)
  - A charged sphere
- Define the ***electric field at a point***: **The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point**. In symbols: $E = \frac{F}{q}$.
- Solve problems using the equation $E = \frac{F}{q}$.
- Calculate the electric field at a point due to a number of point charges, using the equation $E = \frac{kQ}{r^2}$ to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.

Topic 11: Electric Circuits (Grade 11)

Ohm's law

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

Power, energy

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

THIRD TERM

Topic 9: Electric Circuits (Grade 12)

Internal resistance, series and parallel networks

- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors).
- Explain the term *internal resistance*.
- Solve circuit problems using $\varepsilon = V_{load} + V_{internal\ resistance}$ or $\varepsilon = IR_{ext} + Ir$.
- Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).

Topic 10: Electrodynamics (Grade 12)

Electrical machines (generators, motors)

- State the energy conversion in generators.
- Use the principle of electromagnetic induction to explain how a generator works.
- Explain the functions of the components of an AC and a DC generator.
- State examples of the uses of AC and DC generators.
- State the energy conversion in motors.
- Use the motor effect to explain how a motor works.
- Explain the functions of the components of a motor.
- State examples of the use of motors.

Alternating current

- State the advantages of alternating current over direct current.
- Sketch graphs of voltage versus time and current versus time for an AC circuit.
- Define the term *rms* for an alternating voltage or an alternating current. The rms value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.
- Solve problems using $I_{rms} = \frac{I_{max}}{\sqrt{2}}$, $V_{rms} = \frac{V_{max}}{\sqrt{2}}$.
- Solve problems using $P_{ave} = I_{rms}V_{rms} = ½I_{max}V_{max}$ (for a purely resistive circuit), $P_{ave} = I^2_{rms}R$ and $P_{ave} = \frac{V^2_{rms}}{R}$.

Topic 11: Optical Phenomena and Properties of Materials (Grade 12)

Photo-electric effect

- Describe the ***photoelectric effect*** as the **process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.**
- State the significance of the photoelectric effect.
- Define ***threshold frequency***, f_o, as the **minimum frequency of light needed to emit electrons from a certain metal surface**.
- Define ***work function***, W_o, as the **minimum energy that an electron in the metal needs to be emitted from the metal surface.**
- Perform calculations using the photoelectric equation:
  $E = W_o + K_{max}$, where $E = hf$ and $W_o = hf_o$ and $K_{max} = ½mv^2_{max}$
- Explain the effect of intensity and frequency on the photoelectric effect.

Emission and absorption spectra

- Explain the *formation of atomic spectra* by referring to energy transition.
- Explain the difference between *atomic absorption spectra* and *atomic emission spectra*.
  An **atomic absorption spectrum is formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, is absorbed.**
  An atomic emission spectrum is formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.

Topic 12: Electrochemical Reactions (Grade 12)

Electrolytic cells and galvanic cells

- Define the ***galvanic cell*** **as a cell in which chemical energy is converted into electrical energy**. A galvanic (voltaic) cell has self-sustaining electrode reactions.
- Define the ***electrolytic cell*** **as a cell in which electrical energy is converted into chemical energy.**
- Define **oxidation and reduction in terms of electron (e^-) transfer**:
  Oxidation is a loss of electrons. Reduction is a gain of electrons.
- Define **oxidation and reduction in terms of oxidation numbers**:
  Oxidation: An increase in oxidation number
  Reduction: A decrease in oxidation number
- Define an *oxidising agent* and a *reducing agent* in terms of oxidation and reduction:
  Oxidising agent: A substance that is reduced/gains electrons.
  Reducing agent: A substance that is oxidised/loses electrons.
- Define an *anode* and a *cathode* in terms of oxidation and reduction:
  Anode: The electrode where oxidation takes place
  Cathode: The electrode where reduction takes place
- Define an ***electrolyte*** as 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.

Relation of current and potential difference to rate and equilibrium

- Give and explain the relationship between current in an electrolytic cell and the rate of the reaction.
- State that the potential difference of a galvanic cell (V_{cell}) is related to the extent to which the spontaneous cell reaction has reached equilibrium.

- State and use the qualitative relationship between V_{cell} and the concentration of product ions and reactant ions for the spontaneous reaction, namely V_{cell} decreases as the concentration of product ions increases and the concentration of reactant ions decreases until equilibrium is reached at which the $V_{cell} = 0$ (the cell is 'flat'). (Qualitative treatment only. Nernst equation is NOT required.)

Understanding of the processes and redox reactions taking place in galvanic cells

- Describe the movement of ions in the solutions.
- State the direction of electron flow in the external circuit.
- Write down the half-reactions that occur at the electrodes.
- State the function of the salt bridge.
- Use cell notation or diagrams to represent a galvanic cell.
  When writing cell notation, the following convention should be used:
  - The $H_2|H^+$ half-cell is treated just like any other half-cell.
  - Cell terminals (electrodes) are written on the outside of the cell notation.
  - Active electrodes:
    reducing agent | oxidised species || oxidising agent | reduced species
  - Inert electrodes (usually Pt or C):
    Pt | reducing agent | oxidised species || oxidising agent | reduced species | Pt
    Example: Pt | $C\ell^-$(aq) |$C\ell_2$(g) || F_2(g) | F^-(aq) | Pt
- Predict the half-cell in which oxidation will take place when two half-cells are connected.
- Predict the half-cell in which reduction will take place when connected to another half-cell.
- Write down the overall cell reaction by combining two half-reactions.
- Use the Table of Standard Reduction Potentials to calculate the emf of a standard galvanic cell.
- Use a positive value of the standard emf as an indication that the reaction is spontaneous under standard conditions.

Standard electrode potentials

- Write down the standard conditions under which standard electrode potentials are determined.
- Describe the standard hydrogen electrode and explain its role as the reference electrode.
- Explain how standard electrode potentials can be determined using the reference electrode and state the convention regarding positive and negative values.

Understanding the processes and redox reactions taking place in electrolytic cells

- Describe the movement of ions in the solution.
- State the direction of electron flow in the external circuit.
- Write equations for the half-reactions taking place at the anode and cathode.
- Write down the overall cell reaction by combining two half-reactions.
- Describe, using half-reactions and the equation for the overall cell reaction as well as the layout of the particular cell using a schematic diagram, the following electrolytic processes:
  - The decomposition of copper(II) chloride
  - Electroplating, e.g. the electroplating of an iron spoon with silver/nickel
  - Refining of copper
  - The electrolysis of a concentrated solution of sodium chloride and its use in the chlor-alkali industry
  - The recovery of aluminium metal from bauxite (South Africa uses bauxite from Australia.)
- Describe risks to the environment of the following electrolytic processes used industrially:
  - The production of chlorine (the chemical reactions of the chloro-alkali industry)
  - The recovery of aluminium metal from bauxite

Topic 13: Chemical Industry (Grade 12)

The fertiliser industry (N, P, K)

- List, for plants:
    - Three non-mineral nutrients C, H and O and their sources, i.e. the atmosphere (CO_2) and rain (H_2O)
    - Three primary nutrients N, P and K and their sources
- Explain why fertilisers are needed.
- Explain the function of N, P and K in plants.
- Interpret the N : P : K fertiliser ratio and perform calculations based on the ratio.
- Describe, explain, write balanced equations and interpret flow diagrams of the following processes in the industrial manufacture of fertilisers:
    - N_2 – fractional distillation of air
    - H_2 – at SASOL from coal and steam
    - NH_3 – Haber process
    - HNO_3 – Ostwald process
    - H_2SO_4 – Contact process
    - NH_4NO_3; $(NH_4)_2SO_4$
- Evaluate the use of inorganic fertilisers on humans and the environment.
- Define ***eutrophication*** as **the process by which an ecosystem, e.g. a river or dam, becomes enriched with inorganic plant nutrients, especially phosphorus and nitrogen, resulting in excessive plant growth.** As plant growth becomes excessive, the amount of dead and decaying plant material increases rapidly.
- Discuss alternatives to inorganic fertilisers as used by some communities.

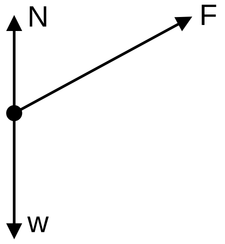
APPENDIX A: SOLVING FORCE PROBLEMS – NEWTON'S SECOND LAW OF MOTION

PROBLEM 1: *A single object moving on a horizontal plane without friction.*

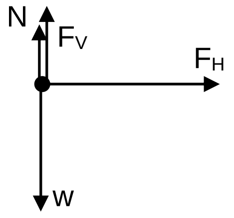
A 15 kg cement block is pulled to the right across a smooth surface with a force of 100 N, which forms an angle of 14° with the horizontal. Calculate the magnitude of the normal force and the acceleration of the cement block. The effects of friction may be ignored.

SOLUTION

Step 1: Draw a free body diagram



OR



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- In this case, the applied force acts at an angle and therefore the normal force is not just equal to the weight of the object. The magnitude of the vertical component of the applied force together with the magnitude of the normal force equals the magnitude of the weight i.e. $w = N + F\sin 14°$.
- The forces in the vertical plane i.e. the normal force, weight and the vertical component of the applied force do not affect the horizontal motion. Only one force i.e. the horizontal component of the applied force, influences horizontal motion.

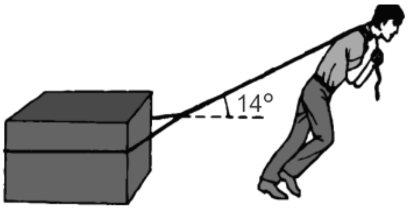
Step 3: Solve

Normal force; upwards positive:
$w + N + F_v = 0$
$mg + N + F\sin 14° = 0$
$-(15)(9,8) + N + 100\sin 14° = 0$ (Use chosen sign convention when substituting.)
$\therefore N = 122,81\ \text{N}$

Acceleration:
To the right as positive:
$F_{net} = ma$
$F\cos 14° = ma$
$(100)\cos 14° = 15a$
$\therefore a = 6,47\ \text{m}\cdot\text{s}^{-2}$
$\therefore a = 6,47\ \text{m}\cdot\text{s}^{-2}$ to the right

Step 4: Evaluate/interpret the answer
The answer is positive – it shows that the acceleration is towards the right.
The normal force is smaller than the weight due to the vertical component of the applied force.

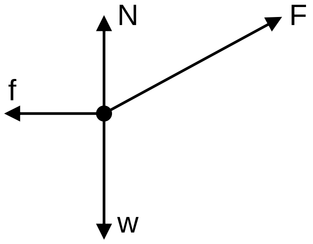
PROBLEM 2: *A single object moving in a horizontal plane with friction.*



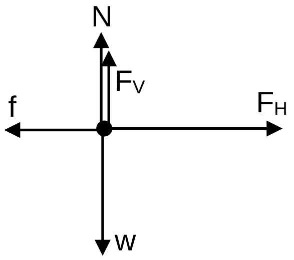
A 15 kg cement block is pulled across the floor with a force of 100 N, which forms an angle of 14° with the horizontal. The coefficient of kinetic friction between the block and the floor is 0,4. Calculate the acceleration of the cement block.

SOLUTION

Step 1: Draw a free body diagram



OR



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- In this case, the applied force acts at an angle and therefore the normal force is not equal to the weight. The magnitude of the vertical component of the applied force together with the magnitude of the normal force equals the magnitude of the weight i.e. $w = N + F\sin 14°$.
- The forces in the vertical plane i.e. the normal force, weight and the vertical component of the applied force do not affect the horizontal motion. Only two forces i.e. friction and the horizontal component of the applied force, influence horizontal motion.
- Although the normal force is not asked in this question, it is needed to calculate the frictional force.

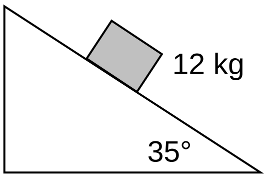
Step 3: Solve

To the right as positive:
$F_{net} = ma$
$F_H + f = ma$ (The net force is the vector sum of all the forces acting on the block.)
$F\cos 14° + \mu_k N = ma$
$F\cos 14° - (0,4)(mg - F\sin 14°) = ma$ (Apply chosen sign convention when substituting.)
$100\cos 14° - (0,4)[(15)(9,8) - 100\sin 14°] = 15a$
$\therefore a = 3,19\ m \cdot s^{-2}$
$\therefore a = 3,19\ m \cdot s^{-2}$ to the right

Step 4: Evaluate/interpret the answer
The answer is positive – it shows that the acceleration is towards the right. The acceleration is smaller than in problem1 due to the presence of a frictional force.

PROBLEM 3: *A single object moving on an inclined plane without friction.*

An inclined surface makes an angle of 35° with the horizontal. Due to an applied force, F, parallel to the surface, the object with mass 12 kg accelerates at 1,5 $m{\cdot}s^{-2}$. Ignoring all frictional forces, calculate the magnitude and direction of F if the:

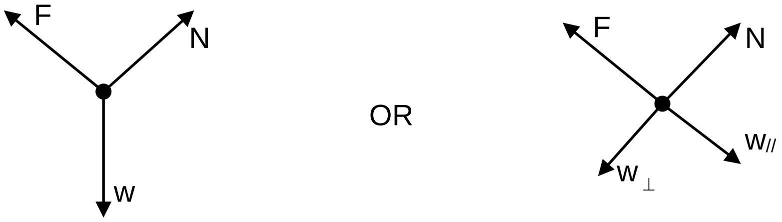


3.1 Acceleration is upwards, along the surface
3.2 Acceleration is downward, along the surface

SOLUTION

Step 1: Draw a free body diagram

3.1 To accelerate upwards, the applied force should act upwards along the inclined plane.



3.2 As above - to have an acceleration smaller than gsin35°, the applied force should act upwards along the inclined plane.

Step 2: Identify the formula
Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- Only the forces or component of forces parallel to the incline will influence motion along the incline i.e. F and mgsin35°.
- In Q3.1, the direction of the acceleration is opposite to that of the component of weight down the incline. In Q3.2 the direction of the acceleration is the same as that of the component of weight down the incline.

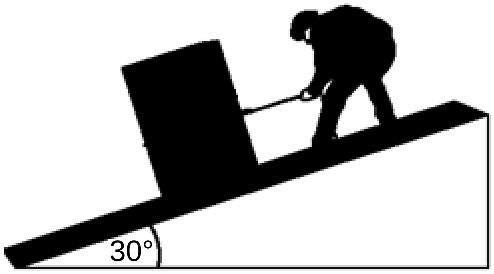
Step 3: Solve
Q3.1:
Upwards along the incline as positive:
$F_{net} = ma$
$F + w_{//} = ma$ (The net force is the vector sum of all the forces acting on the object.)
$F + mg\sin35° = ma$
$F - (12)(9,8)\sin35° = (12)(1,5)$ (Apply chosen sign convention when substituting.)
$\therefore F = 85,45$ N
$\therefore$ F = 85,45 N upwards along the incline

Q3.2:
Upwards along the incline as positive:
$F_{net} = ma$
$F + w_{//} = ma$
$F + mg\sin35° = ma$
$F - (12)(9,8)\sin35° = (12)(-1,5)$ (Apply chosen sign convention when substituting.)
$\therefore F = 49,45$ N
$\therefore$ F = 49,45 N upwards along the incline

Step 4: Evaluate/interpret the answer
Both answers are positive as expected – it shows that the force in both cases acts upwards parallel to the inclined plane.

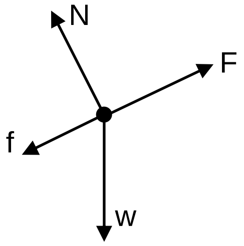
PROBLEM 4: *A single object moving on an inclined plane with friction.*

Richard pulls a crate of mass 20 kg with the help of a rope up along an inclined plane as shown. The tension in the rope is 147 N and the coefficient of kinetic friction between the crate and the inclined plane is 0,1. Calculate the acceleration of the block.

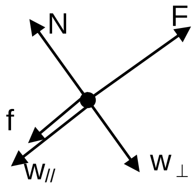


SOLUTION

Step 1: Draw a free body diagram



OR



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- The normal force is needed to calculate the frictional force. The magnitude of the normal force is equal to the magnitude of the component of weight perpendicular to the inclined plane i.e. mgcos30°.
- Three forces will influence the motion on the inclined plane i.e. f, F and $w_{//}$.

Step 3: Solve

Upward along the incline as positive:

$F_{net} = ma$

$F + f + w_{//} = ma$ (The net force is the vector sum of all the forces acting on the block.)

$F + \mu_k N + w_{//} = ma$

$F + \mu_k w_{\perp} + w_{//} = ma$

$F + \mu_k mg\cos30° + mg\sin30° = ma$

$147 - (0,1)(20)(9,8)\cos30° – (20)(9,8)\sin30° = 20a$

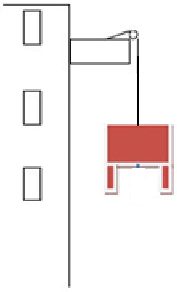
$\therefore a = 1,60\ m{\cdot}s^{-2}$

$\therefore a = 1,60\ m{\cdot}s^{-2}$ upwards along the incline

Step 4: Evaluate the answer

As expected the answer is positive i.e. the direction of motion upwards along the incline.

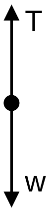
PROBLEM 5: *A single object moving in the vertical plane.*



A company needs to lift a 320 kg piano to the top floor of an apartment building. They use a rope and pulley system to pull the piano up. If the piano has an initial acceleration of 0,45 m·s^{-2}, calculate the tension in the rope.

SOLUTION

Step 1: Draw a free body diagram



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- No normal force is included in the free body diagram. The normal force is a force due to the contact between two surfaces; hence a normal force is a contact force. The piano is not resting on any surface – therefore there is no normal force.

Step 3: Solve

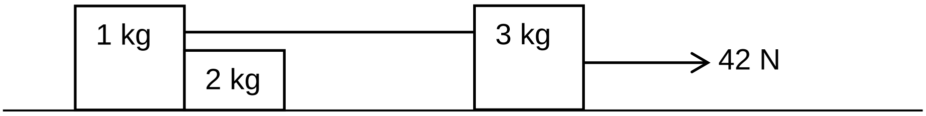
Upward as positive:
$F_{net} = ma$
$T + mg = ma$ (The net force is the vector sum of all the forces acting on the piano.)
$T – (320)(9,8) = (320)(0,45)$ (Apply chosen sign convention when substituting.)
$T = 3\ 280$ N

Step 4: Evaluate the answer

In this problem, the rope exerts an upwards force on the piano. The force by the rope needs to be large enough to support the weight of the piano (3 136 N) and to give it an upwards acceleration. So tension needs to be greater than 3 136 N.

PROBLEM 6: *Two-bodies joined by a light inextensible string, both on a flat horizontal plane without friction.*

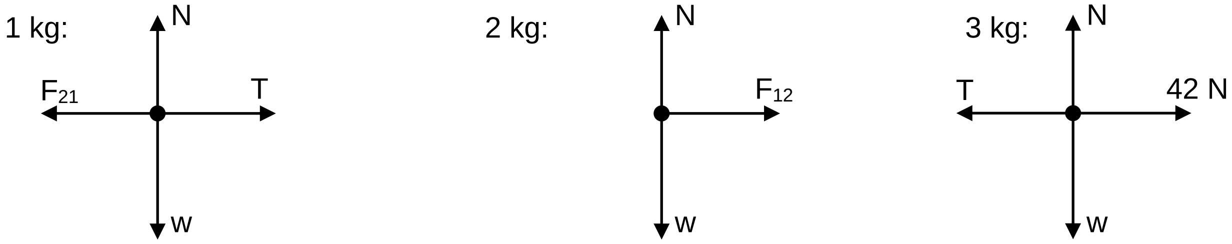
Three blocks of masses 1 kg, 2 kg and 3 kg moves on a horizontal surface under the influence of a force of 42 N as shown. The effect of friction may be ignored.



Calculate the:
6.1 Acceleration of the system
6.2 Tension in rope joining the 1 kg and the 3 kg blocks
6.3 Force exerted by the 1 kg block on the 2 kg block

SOLUTION

Step 1: Draw a free body diagram for each block.



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- In the absence of a frictional force, the applied force is the net force acting on the system.
- To find the tension in the rope and the force exerted by the 1 kg block on the 2 kg block, each block should be isolated and Newton's second law should be applied to each block separately.

Step 3: Solve

To the right as positive:

6.1 $F_{net} = ma$
$42 = (2 + 1 + 3)a$
$a = 7\ m\cdot s^{-2}$ $\therefore a = 7\ m\cdot s^{-2}$ to the right

6.2 Consider the free body diagram of the 3 kg block; to the right as positive:
$F_{net} = ma$
$T + F = ma$
$T + 42 = (3)(7)$
$\therefore T = -21\ N$ $\therefore T = 21\ N$ to the left

6.3 Consider the free body diagrams of the 1 kg or 2 kg blocks; to the right as positive:
For 2 kg block:
$F_{net} = ma$
$F_{12} = (2)(7) = 14$
$\therefore F_{12} = 14\ N$ $\therefore F_{12} = 14\ N$ to the right

OR

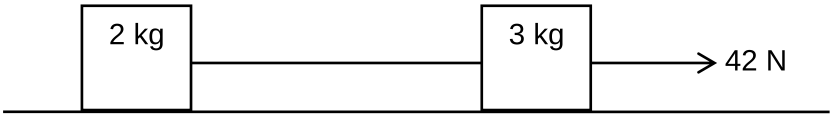
For 1 kg block:
$F_{net} = ma$
$T + F_{21} = ma$
$21 + F_{21} = (1)(7)$
$\therefore F_{21} = -14\ N$ $\therefore F_{12} = 14\ N$ to the right

Step 4: Evaluate the answer

The force exerted by the 1 kg block on the 2 kg is to the right (positive sign according to sign convention) whilst the force exerted by the 2 kg block on the 1 kg block is to the left (negative sign according to sign convention). This is in line with Newton's third law of motion.

PROBLEM 7: *Two bodies joined by a light inextensible string, both on a flat horizontal plane with friction.*

Two blocks of masses 2 kg and 3 kg, joined by a light inelastic string, move on a rough horizontal surface under the influence of a force of 42 N as shown. The coefficients of kinetic friction between the surface and the 2 kg and 3 kg blocks are 0,1 and 0,15 respectively.

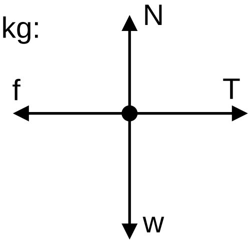


Calculate the tension in the rope joining the two blocks.

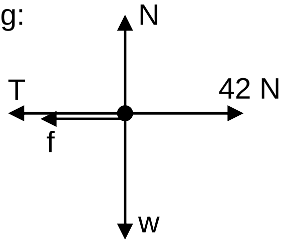
SOLUTION

Step 1: Draw a free body diagram for each block.

2 kg:



3 kg:



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- Both objects experience the same acceleration in the same direction.
- Different frictional forces act on the two blocks – therefore the frictional force on each should be calculated separately.
- To find the tension in the rope, each block should be isolated and Newton's second law should be applied to each block separately. Simultaneous equations must then be used because acceleration is unknown.

Step 3: Solve

Each block is considered separately. An equation with two unknowns is obtained for each block. T is obtained by solving these simultaneous equations.

Important: When using simultaneous equations to solve for the tension in the string joining two objects, it must be remembered that the force that the string exerts on one object is equal, but opposite in direction, to the force that the string exerts on the other object. Therefore, **when composing the two equations, the tension (T) should be given opposite signs.**

Consider the 2 kg block; to the right as positive:

$F_{net} = ma$

$T + f = ma$ (The net force is the vector sum of all the forces acting on the block.)

$T + \mu_k N = ma$

$T + \mu_k mg = ma$

$T - (0,1)(2)(9,8) = 2a$ (T acts to the right and is given a positive sign when substituting.)

$T – 1,96 = 2a$ ……………(1)

Consider the 3 kg block; to the right as positive:

$F_{net} = ma$

$T + f + F = ma$ (The net force is the vector sum of all the forces acting on the block.)

$T + \mu_k N + F = ma$

$T + \mu_k mg + F = ma$

$- T - (0,15)(3)(9,8) + 42 = 3a$ (T acts to the left and is given a negative sign when substituting.)

$- T + 37,59 = 3a$ …………(2)

Equation (1) + equation (2):

$35,63 = 5a$

$\therefore a = 7,13\ m{\cdot}s^{-2}$

$T – 1,96 = 2a$ …………….(1)

$T – 1,96 = 2(7,13)$

$\therefore T = 16,21\ N$

OR

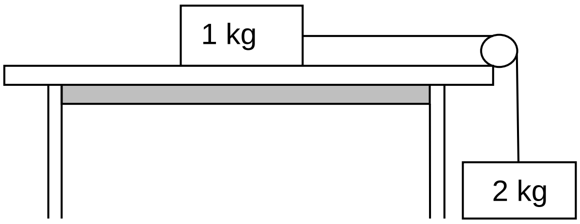
$- T + 37,59 = 3a$ …………(2)

$-T + 37,59 = 3(7,13)$

$\therefore T = 16,21\ N$

PROBLEM 8: *Two bodies joined by a light, inextensible string, one on a horizontal plane without friction, and a second hanging vertically from a string over a light, frictionless pulley.*

In the diagram below, a 1 kg mass on a smooth horizontal surface is joined to a 2 kg mass by a light, inextensible string running over a frictionless pulley.

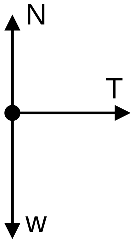


Calculate the tension in the string.

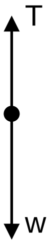
SOLUTION

Step 1: Draw a free body diagram

1 kg:



2 kg:



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.

- No normal force is included in the free body diagram of the 2 kg mass. The normal force is a force due to the contact between two surfaces; hence a normal force is a contact force. The 2 kg mass is not resting on any surface – therefore there is no normal force.
- The magnitude of the acceleration for both masses has the same value *a*. The directions of the accelerations are not the same. The 1 kg mass moves horizontally to the right and the 2 kg mass moves vertically downward.

Step 3: Solve
The two masses are considered separately. From the two free body diagrams, two equations with two unknowns each are obtained. T is obtained by solving these simultaneous equations.

Important: When using simultaneous equations to solve for the tension in the string joining two objects, it must be remembered that the force that the string exerts on one object is equal, but opposite in direction, to the force that the string exerts on the other object. Therefore, **when composing the two equations, the tension (T) should be given opposite signs.**

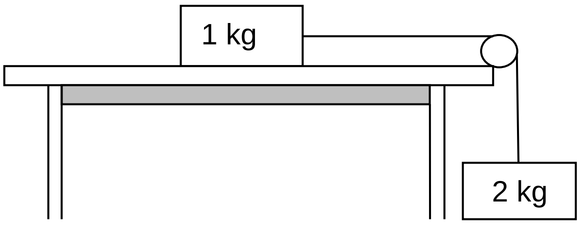
1 kg mass; to the right as positive:
$F_{net} = ma$
$T = ma$ (T acts to the right and is given a positive sign when substituting.)
$T = (1)a$
$\therefore T = a$ ……………………(1)

2 kg mass; downward as positive:
$F_{net} = ma$
$T + w = ma$
$-T + (2)(9,8) = 2a$ (T acts upwards and is given a negative sign when substituting.)
$-T + 19,6 = 2a$ …………..(2)

(1) in (2):
$-T + 19,6 = 2T$
$\therefore T = 6,53$ N

PROBLEM 9: *Two-bodies joined by a light inextensible string, one on a horizontal plane with friction, and a second hanging vertically from a string over a light, frictionless pulley.*

In the diagram below, a 1 kg mass on a rough horizontal surface is joined to a 2 kg mass by a light, inextensible string running over a frictionless pulley. The coefficient of kinetic friction between the 1 kg mass and the surface is 0,13.

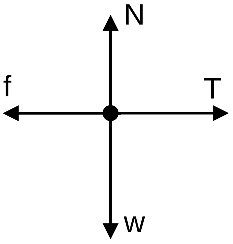


Calculate the tension in the string.

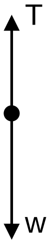
SOLUTION

Step 1: Draw a free body diagram

1 kg:



2 kg:



Step 2: Identify the formula
Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- No normal force is included in the free body diagram of the 2 kg mass. The normal force is a force due to the contact between two surfaces; hence a normal force is a contact force. The 2 kg mass is not resting on any surface – therefore there is no normal force.
- The magnitude of the acceleration for both masses has the same value *a*. The directions of the accelerations are not the same. The 1 kg mass moves horizontally to the right and the 2 kg mass moves vertically downward.
- Only the 1 kg object experiences a frictional force. Therefore two forces act on the 1 kg mass in the horizontal plane. The frictional force is calculated using the formula $f = \mu_k N$.

Step 3: Solve
The two masses are considered separately. From the two free body diagrams, two equations with two unknowns each are obtained. T is obtained by solving these simultaneous equations.

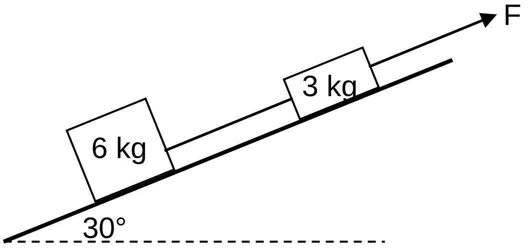
Important: When using simultaneous equations to solve for the tension in the string joining two objects, it must be remembered that the force that the string exerts on one object is equal to but opposite in direction to the force that the string exerts on the other object. Therefore, **when composing the two equations, the tension (T) should be given opposite signs.**

1 kg mass; to the right as positive:
$F_{net} = ma$
$T + f = ma$
$T + \mu_k N = ma$
$T + \mu_k mg = ma$
$T - (0{,}13)(1)(9{,}8) = (1)a$ (T acts to the right and is given a positive sign when substituting.)
$\therefore T - 1{,}27 = a$ ……………………(1)

2 kg mass; downward as positive:
$F_{net} = ma$
$mg + T = ma$
$(2)(9{,}8) - T = 2a$ (T acts upwards and is given a negative sign when substituting.)
$19{,}6 - T = 2a$ ……………………..(2)
(1) in (2):
$19{,}6 - T = 2(T - 1{,}27)$
$\therefore T = 7{,}38$ N

PROBLEM 10: *Two bodies joined by a light inextensible string, both on an inclined plane without friction.*

Two objects of mass 6 kg and 3 kg are connected by a light inelastic string. They are pulled up an inclined plane, which makes an angle of 30° with the horizontal, with a force of magnitude F. The effect of friction and the mass of the string may be ignored.

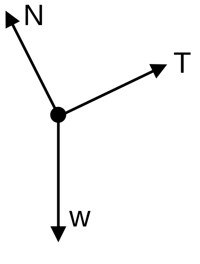


Calculate the:
10.1 Tension in the string if the system accelerates up the inclined plane at 4 $m \cdot s^{-2}$
10.2 Magnitude of F if the system moves up the inclined plane at CONSTANT VELOCITY

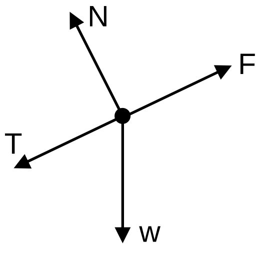
SOLUTION

Step 1: Draw a free body diagram

6 kg:



3 kg:



Step 2: Identify the formula

Points to consider:
- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- In Q10.1, the two objects experience the same acceleration. The acceleration is given and the only way to calculate the tension in the string is to consider the 6 kg object. The 3 kg object has two unknown forces i.e. F and T, acting on it.

- In Q10.2, the acceleration is zero because the objects move up the incline at constant velocity. The net force acting on the system is zero. Note that the tension in the string in this case is different from the tension in Q10.1 where the acceleration is not zero.
- The force exerted by the string on the 6 kg object is equal in magnitude, but opposite in direction to the force exerted on the 3 kg object. Therefore, when substituting, the sign of T in an equation using the 6 kg object will be opposite to that of T when using the 3 kg object.

Step 3: Solve
10.1
The two objects should be considered separately. Usually, from the two free body diagrams, two equations with two unknowns each are obtained. In this case, the acceleration is known and therefore only the 6 kg object is considered. No simultaneous equations will be used.

6 kg object; upwards along the incline as positive:
$F_{net} = ma$
$T + w_{//} = ma$
$T + mg\sin 30° = ma$ (The net force is the vector sum of all the forces acting on the object.)
$T - (6)(9,8)\sin 30° = 6(4)$ (Apply chosen sign convention when substituting.)
$T - 29,4 = 24$
$\therefore T = 53,4\ N$

10.2
Consider the free body diagram of each object separately.

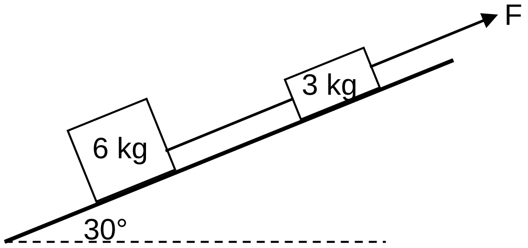
6 kg object; upwards along the incline as positive:
$F_{net} = ma$
$T + w_{//} = ma$
$T + mg\sin 30° = ma$ (The net force is the vector sum of all the forces acting on the object.)
$T - (6)(9,8)\sin 30° = 0$ (T on 6 kg object is upwards along incline, thus positive sign.)
$T - 29,4 = 0$
$\therefore T = 29,4\ N$

3 kg object; upwards along the incline as positive:
$F_{net} = ma$
$F + w_{//} + T = ma$
$F + mg\sin 30° + T = ma$ (The net force is the vector sum of all the forces acting on the object.)
$F - (3)(9,8)\sin 30° - 29,4 = 0$ (T on 3 kg object is downward along incline, thus negative sign.)
$\therefore F = 44,1\ N$

Step 4: Evaluate the answer
An important observation in this problem is that the tension calculated in Q10.1 cannot be substituted when solving Q10.2. The acceleration in Q10.1 differs from that in Q10.2 and therefore the applied force F as well as the tension in the string are different.

PROBLEM 11: *Two bodies joined by a light inextensible string, both on an inclined plane with friction.*

Two objects of mass 6 kg and 3 kg are connected by a light inelastic string. The objects are pulled up an inclined plane which makes an angle of 30° with the horizontal, with a force of magnitude F. The coefficients of kinetic friction for the 3 kg object and 6 kg object are 0,1 and 0,2 respectively.The mass of the string may be ignored.



Calculate the:

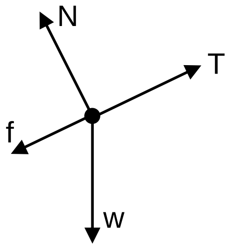
11.1 Tension in the string if the system accelerates up the inclined plane at 4 $m{\cdot}s^{-2}$

11.2 Magnitude of F if the system moves up the inclined plane at CONSTANT VELOCITY

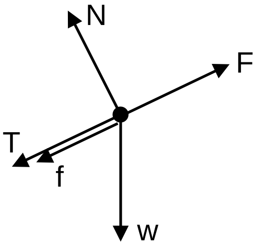
SOLUTION

Step 1: Draw a free body diagram

6 kg:



3 kg:



Step 2: Identify the formula

Points to consider:

- The key equation for any problem that relates forces and motion is Newton's Second Law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- In Q11.1, the two objects experience the same acceleration. The acceleration is given and the only way to calculate the tension in the string is to consider the 6 kg object. The 3 kg object has two unknown forces i.e. F and T, acting on it.
- In Q11.2, the acceleration is zero and the objects move up the incline at constant velocity. The net force acting on the system is zero. Note that the tension in the string in this case will be different from the tension in Q11.1 where the acceleration is not zero.
- The tension in the string exerted on the 6 kg object is equal in magnitude, but opposite in direction to the tension exerted on the 3 kg object. Therefore, when substituting, the sign of T in an equation using the 6 kg object will be opposite to that of T when using the 3 kg object.
- The normal force is needed to calculate the frictional force on each object. The magnitude of the normal force is equal to the magnitude of the component of weight perpendicular to the inclined plane i.e. mgcos30°. The two objects experience different frictional forces and therefore a frictional force for each, using the normal force exerted on each, should be calculated.

Step 3: Solve

11.1

The two objects are considered separately. Usually, from the two free body diagrams, two equations with two unknowns each are obtained. In this case, the acceleration is known and therefore only the 6 kg object is considered. No simultaneous equations will thus be used.

6 kg object; upwards along the incline as positive:

$F_{net} = ma$

$T + f + w_{//} = ma$ (The net force is the vector sum of all the forces acting on the object.)

$T + \mu_k N + mg\sin 30° = ma$

$T + \mu_k mg\cos 30° + mg\sin 30° = ma$

$T – (0,2)(6)(9,8)\cos 30° - (6)(9,8)\sin 30° = 6(4)$

$\therefore T = 63,58$ N

11.2

Consider the free body diagram of each object separately. Usually, from the two free body diagrams, two equations with two unknowns each are obtained. In this case, the acceleration is known and therefore the 6 kg object is used to calculate T.

6 kg; upwards along the incline as positive:

$F_{net} = ma$

$T + f + w_{//} = ma$

$T + \mu_k N_{6\ kg} + mg\sin 30° = ma$

$T + \mu_k mg\cos 30° + mg\sin 30° = ma$

$T – (0,2)(6)(9,8)\cos 30° - (6)(9,8)\sin 30° = 0$

$T – 39,58 = 0 \therefore T = 39,58$ N

3 kg; upwards along the incline as positive:

$F_{net} = ma$

$F + f + w_{//} + T = ma$

$F + \mu_k N_{3\ kg} + mg\sin 30° + T = ma$

$F + \mu_k mg\cos 30° + mg\sin 30° + T = ma$

$F – (0,1)(3)(9,8)\cos 30° - (3)(9,8)\sin 30° - 39,58 = 0$

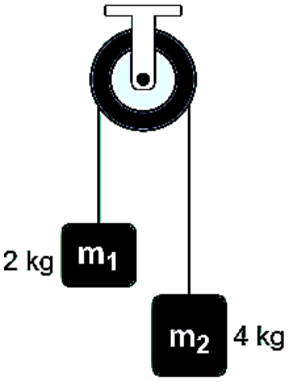
$\therefore F = 56,83$ N

Step 4: Evaluate the answer

Due to the presence of frictional forces, the tension in Q11.1 is greater than that in Q10.1. Also, due to the presence of frictional forces, the applied force in Q11.2 is greater than that in Q10.2.

PROBLEM 12: *Two bodies joined by a light inextensible string, both hanging vertically from a string over a frictionless pulley.*

Two blocks, one with a mass of 2 kg and the other with a mass of 4 kg, hang over a frictionless pulley on a thin, light rope.



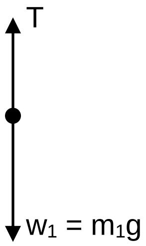
Calculate the:

12.1 Acceleration of the blocks
12.2 Tension in the rope

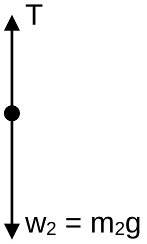
SOLUTION

Step 1: Draw a free body diagram

2 kg:



4 kg:



Step 2: Identify the formula
Points to consider:

- The key equation for any problem that relates forces and motion is Newton's second law. Regardless of what quantity you are asked to find, begin with the Second Law i.e. $F_{net} = ma$.
- Because the pulley turns easily (is frictionless), the tension in the rope is the same on both sides. Because the rope does not stretch, the magnitude of the acceleration will be the same for both blocks.
- The 2 kg block will accelerate upwards and the 4 kg block will accelerate downward.
- In problems like this one, it is convenient to consider the direction of motion as positive. The tension in the rope on the two objects will be equal in magnitude but opposite in direction.

Step 3: Solve
12.1
Consider the free body diagram of each object separately.

Important: When using simultaneous equations to solve for the tension in the string joining two objects, it must be remembered that the force that the string exerts on one object is equal to but opposite in direction to the force that the string exerts on the other object. Therefore, **when composing the two equations, the tension (T) should be given opposite signs.**

2 kg object; upwards (direction of motion) positive:
$F_{net} = ma$
$T + w_1 = m_1a$
$T + m_1g = m_1a$
$T - (2)(9,8) = 2a$ (T on 2 kg object is upwards, thus positive sign.)
$T - 19,6 = 2a$
$T = 19,6 + 2a$ ………………..(1)

For the 4 kg object, downward (direction of motion) positive:
$F_{net} = ma$
$w_2 + T = m_2a$
$m_2g + T = m_2a$
$(4)(9,8) - T = 4a$ (T on 4 kg object is upwards, thus negative sign.)
$39,2 - T = 4a$
$-T = -39,2 + 4a$
$T = 39,2 - 4a$ ……………….(2)

Equation (1) into equation (2):
$19,6 + 2a = 39,2 - 4a \therefore a = 3,27 \text{ m·s}^{-2}$
The 2 kg block accelerates at $3,27 \text{ m·s}^{-2}$ upwards
The 4 kg block accelerates at $3,27 \text{ m·s}^{-2}$ downward.

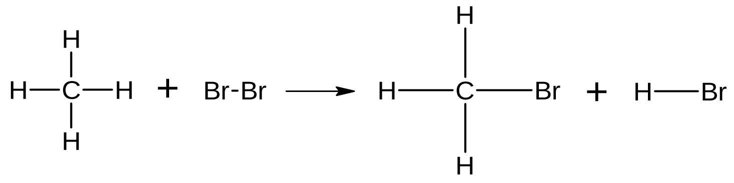
12.2
From equation (1) for 2 kg object:
$T = 19,6 + 2a$
$= 19,6 + 2(3,27) = 26,14 \text{ N}$

OR
From equation (2) for 4 kg object:
$T = 39,2 - 4a = 39,2 - 4(3,27) = 26,14 \text{ N}$

APPENDIX B: Organic reactions

REACTIONS OF ALKANES

SUBSTITUTION
Alkane → haloalkane

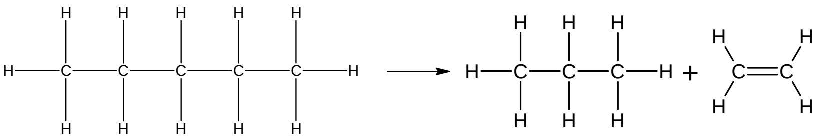


Conditions: heat OR sunlight **Reactants:** alkane + X_2 (F, Cl, Br, I)
Type of substitution: halogenation **Products**: haloalkane + HX

OXIDATION (COMBUSTION)

$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$
Alkane + oxygen → carbon dioxide + water + **energy**

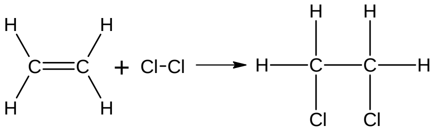
ELIMINATION
Alkane → alkene(s) + alkane with shorter chain



Type of elimination: (thermal) cracking
Conditions: heat + high pressure
Reactant: alkane
Products: alkene(s) + alkane / alkene + H_2

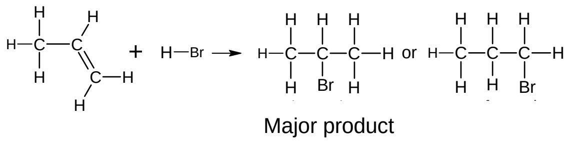
REACTIONS OF ALKENES

ADDITION



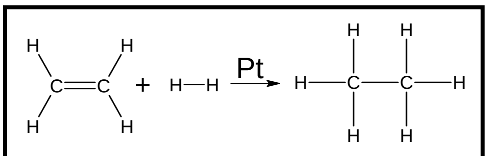
Conditions: unreactive solvent
Type of addition: halogenation
Reactants: alkene + X_2 (X = Cl, Br)
Product: haloalkane

ADDITION



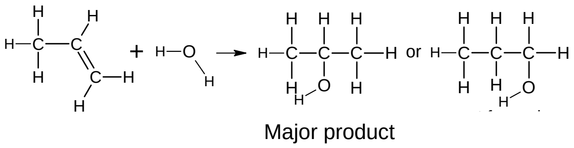
Conditions: no water; unreactive solvent
Type of addition: hydrohalogenation
Reactants: alkene + HX (X = I, Br, Cl)
Product(s): haloalkane(s)
Major product: H atom bonds to the C atom already having the greater number of H atoms.

ADDITION

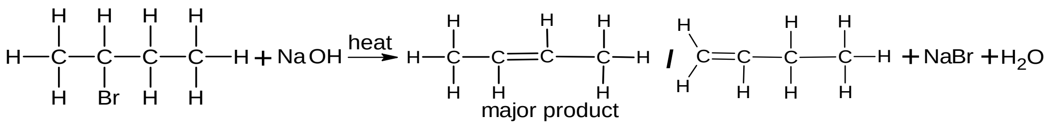


Conditions: Pt, Pd or Ni as catalyst
Type of addition: hydrogenation
Reactants: alkene + H_2
Product: alkane

ADDITION



Conditions: excess H_2O; small amount of acid (H_2SO_4/H_3PO_4) as catalyst
Type of addition: hydration
Reactants: alkene + H_2O
Product: alcohol(s)
Major product: H atom bonds to the C atom already having the greater number of H atoms.

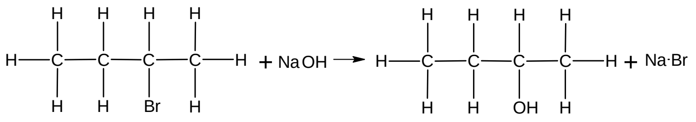


Conditions: concentrated strong base (NaOH, KOH, LiOH) in ethanol + heat
Type of elimination: dehydrohalogenation
Reactants: haloalkane + concentrated strong base **Products:** alkene + NaBr + H_2O
Major product: The one where the H atom is removed from the C atom with the least number of H atoms (most substituted double bond forms i.e. double bond with most alkyl groups)

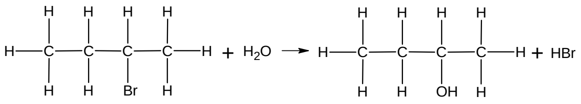
ELIMINATION

REACTIONS OF HALOALKANES

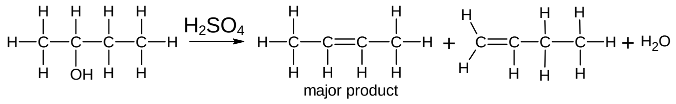
SUBSTITUTION



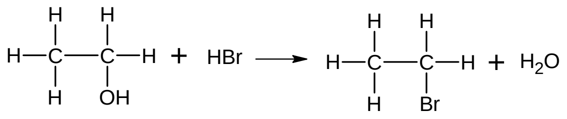
Conditions: dilute strong base (NaOH/KOH/LiOH) + mild heat
Type of substitution: hydrolysis
Reactants: haloalkane + dilute strong base
Products: alcohol + NaBr/KBr/LiBr



Conditions: excess H_2O + mild heat
Type of substitution: hydrolysis
Reactants: haloalkane + H_2O
Products: alcohol + HBr



Conditions: dehydrating agent (H_2SO_4 + heat
Type of elimination: dehydration
Reactants: alcohol + H_2SO_4
Products: alkene(s) + H_2O
Major product: The one where the H atom is removed from the C atom with the least number of H atoms



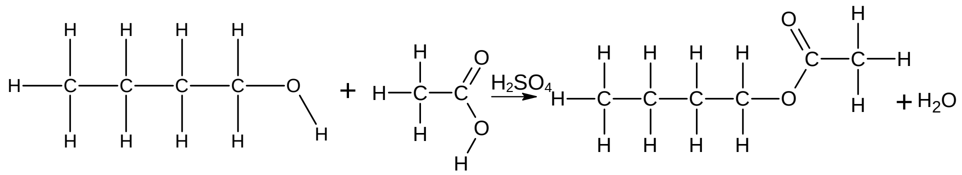
Conditions: heat
Reactants needed: alcohol + HX
Primary & secondary alcohols:
NaBr + H_2SO_4 used to make HBr in reaction flask
Tertiary alcohols: water free HBr (or HCl)
Products: haloalkane + H_2O

ELIMINATION
Alcohol → alkene

SUBSTITUTION

REACTIONS OF ALCOHOLS

ESTERIFICATION



Conditions: concentrated sulphuric acid as catalyst + heat **Type:** esterification
Reactants: alcohol + carboxylic acid **Products:** ester + water

APPENDIX C: DATA SHEETS

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	**SYMBOL/*SIMBOOL***	**VALUE/*WAARDE***
Acceleration due to gravity *Swaartekragversnelling*	g	9,8 $m \cdot s^{-2}$
Universal gravitational constant *Universele gravitasiekonstant*	G	6,67 x 10^{-11} $N \cdot m^2 \cdot kg^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	3,0 x 10^8 $m \cdot s^{-1}$
Planck's constant *Planck se konstante*	h	6,63 x 10^{-34} $J \cdot s$
Coulomb's constant *Coulomb se konstante*	k	9,0 x 10^9 $N \cdot m^2 \cdot C^{-2}$
Charge on electron *Lading op elektron*	e	1,6 x 10^{-19} C
Electron mass *Elektronmassa*	m_e	9,11 x 10^{-31} kg
Mass of the Earth *Massa van die Aarde*	M	5,98 x 10^{24} kg
Radius of the Earth *Radius van die Aarde*	R_E	6,38 x 10^6 m

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or/*of* $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or/*of* $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ or/*of* $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$

FORCE/*KRAG*

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\frac{m_1 m_2}{d^2}$ or/*of* $F = G\frac{m_1 m_2}{r^2}$	$g = G\frac{M}{d^2}$ or/*of* $g = G\frac{M}{r^2}$

WORK, ENERGY AND POWER/*ARBEID, ENERGIE EN DRYWING*

$W = F\Delta x \cos\theta$	$U = mgh$ or/*of* $E_P = mgh$
$K = \frac{1}{2}mv^2$ or/*of* $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ or/*of* $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or/*of* $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or/*of* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$ / $P_{gemid} = Fv_{gemid}$	

WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s}f_s$ $f_L = \frac{v \pm v_L}{v \pm v_b}f_b$	$E = hf$ or/*of* $E = h\frac{c}{\lambda}$
$E = W_o + E_{k(max)}$ or/*of* $E = W_o + K_{max}$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_{k(max)} = \frac{1}{2}mv_{max}^2$ or/*of* $K_{max} = \frac{1}{2}mv_{max}^2$	

ELECTROSTATICS/*ELEKTROSTATIKA*

$F=\frac{kQ_1Q_2}{r^2}$	$E=\frac{kQ}{r^2}$
$V=\frac{W}{q}$	$E=\frac{F}{q}$
$n=\frac{Q}{e}$ or/*of* $n=\frac{Q}{q_e}$	

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

$R=\frac{V}{I}$	emf $(\varepsilon) = I(R + r)$ emk $(\varepsilon) = I(R + r)$
$R_s = R_1 + R_2 + ...$ $\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}+ ...$	$q = I\ \Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P=\frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P=\frac{V^2}{R}$

ALTERNATING CURRENT/*WISSELSTROOM*

$I_{rms}=\frac{I_{max}}{\sqrt{2}}$ / $I_{wgk}=\frac{I_{maks}}{\sqrt{2}}$ $V_{rms}=\frac{V_{max}}{\sqrt{2}}$ / $V_{wgk}=\frac{V_{maks}}{\sqrt{2}}$	$P_{ave}=V_{rms}I_{rms}$ / $P_{gemiddeld}=V_{wgk}I_{wgk}$ $P_{ave}=I_{rms}^2R$ / $P_{gemiddeld}=I_{wgk}^2R$ $P_{ave}=\frac{V_{rms}^2}{R}$ / $P_{gemiddeld}=\frac{V_{wgk}^2}{R}$

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

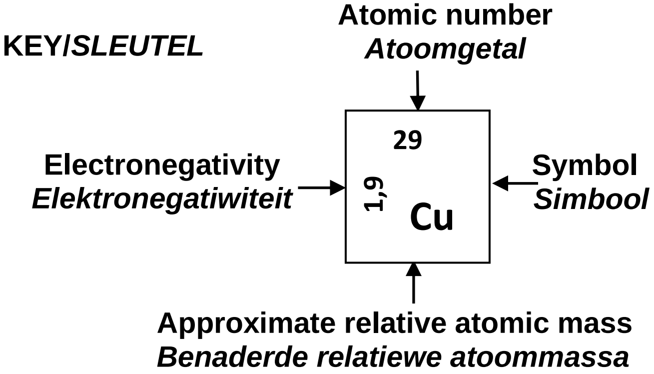
NAME/*NAAM*	**SYMBOL/*SIMBOOL***	**VALUE/*WAARDE***
Standard pressure *Standaarddruk*	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^θ	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_{bV_b}} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ / $E^\theta_{sel} = E^\theta_{katode} - E^\theta_{anode}$ or/*of* $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ / $E^\theta_{sel} = E^\theta_{reduksie} - E^\theta_{oksidasie}$ or/*of* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*



1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 **H** 1																	2 **He** 4
3 1,0 **Li** 7	4 1,5 **Be** 9											5 2,0 **B** 11	6 2,5 **C** 12	7 3,0 **N** 14	8 3,5 **O** 16	9 4,0 **F** 19	10 **Ne** 20
11 0,9 **Na** 23	12 1,2 **Mg** 24											13 1,5 **Aℓ** 27	14 1,8 **Si** 28	15 2,1 **P** 31	16 2,5 **S** 32	17 3,0 **Cℓ** 35,5	18 **Ar** 40
19 0,8 **K** 39	20 1,0 **Ca** 40	21 1,3 **Sc** 45	22 1,5 **Ti** 48	23 1,6 **V** 51	24 1,6 **Cr** 52	25 1,5 **Mn** 55	26 1,8 **Fe** 56	27 1,8 **Co** 59	28 1,8 **Ni** 59	29 1,9 **Cu** 63,5	30 1,6 **Zn** 65	31 1,6 **Ga** 70	32 1,8 **Ge** 73	33 2,0 **As** 75	34 2,4 **Se** 79	35 2,8 **Br** 80	36 **Kr** 84
37 0,8 **Rb** 86	38 1,0 **Sr** 88	39 1,2 **Y** 89	40 1,4 **Zr** 91	41 **Nb** 92	42 1,8 **Mo** 96	43 1,9 **Tc**	44 2,2 **Ru** 101	45 2,2 **Rh** 103	46 2,2 **Pd** 106	47 1,9 **Ag** 108	48 1,7 **Cd** 112	49 1,7 **In** 115	50 1,8 **Sn** 119	51 1,9 **Sb** 122	52 2,1 **Te** 128	53 2,5 **I** 127	54 **Xe** 131
55 0,7 **Cs** 133	56 0,9 **Ba** 137	57 **La** 139	72 1,6 **Hf** 179	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 201	81 1,8 **Tℓ** 204	82 1,8 **Pb** 207	83 1,9 **Bi** 209	84 2,0 **Po**	85 2,5 **At**	86 **Rn**
87 0,7 **Fr**	88 0,9 **Ra** 226	89 **Ac**															

58 **Ce** 140	59 **Pr** 141	60 **Nd** 144	61 **Pm**	62 **Sm** 150	63 **Eu** 152	64 **Gd** 157	65 **Tb** 159	66 **Dy** 163	67 **Ho** 165	68 **Er** 167	69 **Tm** 169	70 **Yb** 173	71 **Lu** 175
90 **Th** 232	91 **Pa**	92 **U** 238	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARDREDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↑

Half-reactions/*Halfreaksies*			**E^{θ} (V)**
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$Na^+ + e^-$	⇌	Na	− 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	− 2,93
$Li^+ + e^-$	⇌	Li	− 3,05

Increasing reducing ability/*Toenemende reduserende vermoë* ↓

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARDREDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,05
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,93
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	– 2,92
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	– 2,89
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,36
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,91
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	– 0,74
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	– 0,44
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	– 0,41
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	– 0,40
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	– 0,28
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	– 0,27
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	– 0,06
$2H^+ + 2e^-$	**$\rightleftharpoons$**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

Increasing reducing ability/*Toenemende reduserende vermoë*

APPENDIX D: What must I prepare for each control test / examination?

GRADE 12 MARCH CONTROL TEST (ONE PAPER: 100 MARKS)

KNOWLEDGE AREA (KA) & Topic (The numbers in front of the KA and topic are the numbers in the annual teaching plan)	**Approximate mark per topic**	**Approximate mark per KA**
2. MECHANICS: Newton's laws (From grade 11) • Different kinds of. • Static and kinetic frictional forces • Force diagrams, free body diagrams. • Newton's first law. • Newton's second law • Force diagrams & free body diagrams. • Apply Newton's laws to a variety of equilibrium and non-equilibrium problems. • Understand apparent weight. • Newton's third law. • Newton's Law of Universal Gravitation	20	60
1. MECHANICS: Momentum & Impulse • Define & calculate the momentum of a moving object: $p = mv$ • Describe the vector nature of momentum & draw vector diagrams. • State Newton's second law in terms of momentum: $F_{net}= \frac{\Delta p}{\Delta t}$ • Calculate the change in momentum when a resultant force acts on an object. • Define impulse & deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$. • Use this theorem to calculate the force exerted, time for which the force is applied and change in momentum for a variety of situations (one dimension). • Explain how the concept of impulse applies to safety considerations. • State the principle of conservation of linear momentum. • Explain what is meant by an isolated system, internal and external forces • Apply conservation of momentum to collisions of two objects (one dimension). • Distinguish between elastic and inelastic collisions by calculation.	16	
2. MECHANICS: Vertical projectile motion • Explain what is meant by a projectile and use equations of motion to determine the position, velocity and displacement of a projectile at any given time. • Sketch x vs t, v vs t and a vs t graphs for a free falling object, an object thrown vertically upwards, an object thrown vertically downwards & bouncing objects. • For a given x vs t, v vs t or a vs t graphs determine position, displacement and velocity or acceleration at any time t. • For a given x vs t, v vs t or a vs t graphs describe the motion of the object bouncing, thrown vertically upwards & thrown vertically downward.	24	
4. MATTER & MATERIALS: Intermolecular forces (From grade 11) • Intermolecular & interatomic forces (chemical bonds). • Different intermolecular forces. • Intermolecular forces and density, boiling point, melting point. • Particle kinetic energy and temperature. • The chemistry of water.	8	40
3. MATTER & MATERIALS: Organic molecules • Define the terms organic molecules, functional group, hydrocarbon, homologous series, saturated, unsaturated and structural isomer. • Write condensed, structural & molecular formulae (up to 8 C atoms, 1 functional group per molecule) for alkanes (no rings), alkenes (no rings), alkynes, haloalkanes (no rings), alcohols, carboxylic acids, esters, aldehydes & ketones • Write the IUPAC name when given the structural or condensed structural formula for compounds from the above 'homologous series' (one functional group per compound, max. two functional groups for haloalkanes). • Identify alkyl substituents (methyl- and ethyl-); max. THREE alkyl substituents. • Identify compounds that are saturated, unsaturated & are structural isomers (only chain isomers, positional isomers and functional isomers). • Physical properties: Explain the relationship between boiling point / melting point / vapour pressure (for any of above compounds) and strength of IMF, type of functional groups, chain length and branched chains.	32	
TOTAL OF PAPER	**100**	**100**

GRADE 12 JUNE EXAMINATION (PAPER 1: 150 MARKS)

KNOWLEDGE AREA (KA) & Topic (The numbers in front of the KA and topic are the numbers in the annual teaching plan)	**Approximate mark per topic**	**Approximate mark per KA**
2. MECHANICS: Newton's laws (From grade 11) (From grade 11) • Different kinds of forces. • Static and kinetic frictional forces • Force diagrams, free body diagrams. • Newton's first law. • Newton's second law • Force diagrams & free body diagrams. • Apply Newton's laws to a variety of equilibrium and non-equilibrium problems. • Understand apparent weight. • Newton's third law. • Newton's Law of Universal Gravitation	30	95
1. MECHANICS: Momentum & Impulse • Define & calculate the momentum of a moving object: p = mv • Describe the vector nature of momentum & draw vector diagrams. • State Newton's second law in terms of momentum: $F_{net} = \frac{\Delta p}{\Delta t}$ • Calculate the change in momentum when a resultant force acts on an object. • Define impulse & deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$. • Use this theorem to calculate the force exerted, time for which the force is applied and change in momentum for a variety of situations (one dimension). • Explain how the concept of impulse applies to safety considerations. • State the principle of conservation of linear momentum. • Explain what is meant by an isolated system, internal and external forces • Apply conservation of momentum to collisions of two objects (one dimension). • Distinguish between elastic and inelastic collisions by calculation.	19	
2. MECHANICS: Vertical projectile motion • Explain what is meant by a projectile and use equations of motion to determine the position, velocity and displacement of a projectile at any given time. • Sketch x vs t, v vs t and a vs t graphs for a free falling object, an object thrown vertically upwards, an object thrown vertically downwards & bouncing objects. • For a given x vs t, v vs t or a vs t graphs determine position, displacement and velocity or acceleration at any time t. • For a given x vs t, v vs t or a vs t graphs describe the motion of the object bouncing, thrown vertically upwards & thrown vertically downward.	24	
4. MECHANICS: Work, energy and power • Define the work done on an object; Draw force diagram & free-body diagrams. • Calculate the net work done on an object. • Distinguish between positive work and negative net work done on the system. • Define the work-energy theorem. • Apply the work-energy theorem on horizontal, vertical and inclined planes. • Define conservative and non-conservative forces and give examples. • State the principle of conservation of mechanical energy. • Solve problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$ • Show that E_{mech} is conserved in absence of non-conservative forces. • Define power and calculate the power involved when work is done. • Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane. • Calculate the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate using $W_{nc} = \Delta E_k + \Delta E_p$.	22	
5. WAVES, SOUND & LIGHT: Doppler Effect • State the Doppler effect and explain (using illustrations) the change in pitch observed when a source moves toward or away from a listener (sound and ultra-sound). State applications of the Doppler effect. • Solve problems using $f_L = \frac{v \pm v_L}{v \pm v_S} f_s$ when EITHER source or listener moves. • With light, explain 'red shifts' & use the Doppler Effect to explain why we conclude that the universe is expanding.	15	15
9. ELECTRICITY & MAGNETISM: Electrostatics (From grade 11) • Coulomb's Law • Force exerted on a charge by one or more charges in one dimension (1D) and two dimensions (2D). • Electric field and its direction. • Electric field patterns for various configurations of charges. • Magnitude of the electric field at a point as the force per unit charge. • Calculate the electric field at a point:	20	40
11. ELECTRICITY & MAGNETISM: Electric circuits (From grade 11) • Relationship between current, potential difference (voltage) and resistance. • Ohmic and non-ohmic conductors. • Ohm's law for series and parallel circuits. • Power measured in watt (W). • Electrical power dissipated in a device. • Electrical energy, kilowatt hour (kWh) & cost of electricity.	20	
TOTAL OF PAPER	**150**	**150**

GRADE 12 JUNE EXAMINATION (PAPER 2: 150 MARKS)

KNOWLEDGE AREA (KA) & Topic (The numbers in front of the KA and topic are the numbers in the annual teaching plan)	**Approximate mark per topic**	**Approximate mark per KA**
4. MATTER & MATERIALS: Intermolecular forces (From grade 11) • Intermolecular & interatomic forces (chemical bonds). • Different intermolecular forces: ion-dipole, ion-induced dipole, dipole-dipole, dipole-induced dipole, induced dipole, hydrogen bonds. • Intermolecular forces and density, boiling point, melting point. • Particle kinetic energy and temperature. • The chemistry of water.	10	50
3. MATTER & MATERIALS: Organic molecules • Define the terms organic molecules, functional group, hydrocarbon, homologous series, saturated, unsaturated and structural isomer. • Write condensed, structural & molecular formulae (up to 8 C atoms, 1 functional group per molecule) for alkanes (no rings), alkenes (no rings), alkynes, haloalkanes (no rings), alcohols, carboxylic acids, esters, aldehydes & ketones • Write the IUPAC name when given the structural or condensed structural formula for compounds from the above 'homologous series' (one functional group per compound, max. two functional groups for haloalkanes). • Identify alkyl substituents (methyl- and ethyl-); max. THREE alkyl substituents. • Identify compounds that are saturated, unsaturated & are structural isomers (only chain isomers, positional isomers and functional isomers). • Physical properties: Explain the relationship between boiling point / melting point / vapour pressure (for any of above compounds) and strength of IMF, type of functional groups, chain length and branched chains. • Oxidation of alkanes: State the use of alkanes as fuels & write an equation for the combustion of an alkane in excess oxygen. • Esterification: Write an equation & reaction conditions for the formation of an ester and name the alcohol and carboxylic acid used and the ester formed. • Identify reactions as elimination, substitution or addition. • Write equations and reaction conditions for the following addition reactions of alkenes: hydrohalogenation, halogenation, hydration, hydrogenation • Write equations and reaction conditions for elimination reactions: dehydro-halogenation of haloalkanes, dehydration of alcohols & cracking of alkanes • Write equations and reaction conditions for substitution reactions: hydrolysis of haloalkanes, reactions of HX (X = Cℓ , Br) with alcohols to produce haloalkanes, halogenation of alkanes • Plastics & polymers: Polymer, macromolecule, chain, monomer, functional group. • Polymerization of ethene to form polythene - equation & industrial uses. • Distinguish between addition & condensation polymers (polyesters).	40	
13. CHEMICAL CHANGE: Representing chemical change (From grade 10) • Balanced chemical equations	20	100
8. CHEMICAL CHANGE: Quantitative aspects of chemical change (From grade 11) • Molar volume of gases. • Volume relationships for gases. • Concentration of solutions. • Stoichiometric calculations including limiting reagents. • Calculate percentage yield of a chemical reaction. • Determine empirical formula and molecular formula. • Determine percentage purity or percentage composition.		
12. CHEMICAL CHANGE: Energy & chemical change (from grade 11) • Enthalpy and its relationship to heat of reaction. • Exothermic and endothermic reactions and potential energy graphs. • Activation energy.	12	
6. CHEMICAL CHANGE: Rate and extent of reaction • Explain what is meant by reaction rate & list factors which affect reaction rate. • Explain in terms of collision theory how various factors affect the rate. • Write down experimental techniques for measuring the rate of a given reaction. • Define the term catalyst and explain how a catalyst increases reaction rate. • Interpret graphs of distribution of molecular energies to explain how a catalyst & temperature affect rate.	26	
7. CHEMICAL CHANGE: Chemical equilibrium • Explain: open & closed systems; reversible reactions; dynamic equilibrium • List the factors which influence the position of an equilibrium. • State Le Chatelier's principle and use it to explain changes in equilibria. • Interpret simple graphs of equilibrium. • Explain the use of rate & equilibrium principles in the Haber & Contact process. • List the factors which influence the value of the equilibrium constant K_c. • Write an expression for the equilibrium constant from a given equation. • Perform calculations based on K_c values and • Explain the significance of high and low values of the equilibrium constant.	26	
8. CHEMICAL CHANGE: Acids and bases • Define acids and bases according to Arrhenius and Lowry-Brønsted. • Distinguish between strong and weak acids/bases with examples. • Distinguish between concentrated and dilute acids/bases. • Identify conjugate acid-base pairs for given compounds. • Write neutralisation reactions of common laboratory acids and bases. • Perform calculations based on titration reactions & motivate choice of indicator.	16	
TOTAL OF PAPER	**150**	**150**

GRADE 12 SEPTEMBER EXAMINATION (PAPER 1: 150 MARKS)

KNOWLEDGE AREA (KA) & Topic (The numbers in front of the KA and topic are the numbers in the annual teaching plan)	**Approximate mark per topic**	**Approximate mark per KA**
2. MECHANICS: Newton's laws (From grade 11) (From grade 11) • Different kinds of forces. • Static and kinetic frictional forces • Force diagrams, free body diagrams. • Newton's first law. • Newton's second law • Force diagrams & free body diagrams. • Apply Newton's laws to a variety of equilibrium and non-equilibrium problems. • Understand apparent weight. • Newton's third law. • Newton's Law of Universal Gravitation	15–25	63
1. MECHANICS: Momentum & Impulse • Define & calculate the momentum of a moving object: p = mv • Describe the vector nature of momentum & draw vector diagrams. • State Newton's second law in terms of momentum: $F_{net} = \frac{\Delta p}{\Delta t}$ • Calculate the change in momentum when a resultant force acts on an object. • Define impulse & deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$. • Use this theorem to calculate the force exerted, time for which the force is applied and change in momentum for a variety of situations (one dimension). • Explain how the concept of impulse applies to safety considerations. • State the principle of conservation of linear momentum. • Explain what is meant by an isolated system, internal and external forces • Apply conservation of momentum to collisions of two objects (one dimension). • Distinguish between elastic and inelastic collisions by calculation.	10–20	
2. MECHANICS: Vertical projectile motion • Explain what is meant by a projectile and use equations of motion to determine the position, velocity and displacement of a projectile at any given time. • Sketch x vs t, v vs t and a vs t graphs for a free falling object, an object thrown vertically upwards, an object thrown vertically downwards & bouncing objects. • For a given x vs t, v vs t or a vs t graphs determine position, displacement and velocity or acceleration at any time t. • For a given x vs t, v vs t or a vs t graphs describe the motion of the object bouncing, thrown vertically upwards & thrown vertically downward.	10–20	
4. MECHANICS: Work, energy and power • Define the work done on an object; Draw force diagram & free-body diagrams. • Calculate the net work done on an object. • Distinguish between positive work and negative net work done on the system. • Define the work-energy theorem. • Apply the work-energy theorem on horizontal, vertical and inclined planes. • Define conservative and non-conservative forces and give examples. • State the principle of conservation of mechanical energy. • Solve problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$ • Show that E_{mech} is conserved in absence of non-conservative forces. • Define power and calculate the power involved when work is done. • Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane. • Calculate the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate using $W_{nc} = \Delta E_k + \Delta E_p$.	10–20	
5. WAVES, SOUND & LIGHT: Doppler Effect • State the Doppler effect and explain (using illustrations) the change in pitch observed when a source moves toward or away from a listener (sound and ultra-sound). State applications of the Doppler effect. • Solve problems using $f_L = \frac{v \pm v_L}{v \pm v_S} f_s$ when EITHER source or listener moves. • With light, explain 'red shifts' & use the Doppler Effect to explain why we conclude that the universe is expanding.	10–17	17

GRADE 12 SEPTEMBER EXAMINATION (PAPER 1: 150 MARKS)/Continue ...

9. ELECTRICITY & MAGNETISM: Electrostatics (From grade 11) • Coulomb's Law • Force exerted on a charge by one or more charges in one dimension (1D) and two dimensions (2D). • Electric field and its direction. • Electric field patterns for various configurations of charges. • Magnitude of the electric field at a point as the force per unit charge. • Calculate the electric field at a point.	15–20	55
11. ELECTRICITY & MAGNETISM: Electric circuits (From grade 11) • Relationship between current, potential difference (voltage) and resistance. • Ohmic and non-ohmic conductors. • Ohm's law for series and parallel circuits. • Power measured in watt (W). • Electrical power dissipated in a device. • Electrical energy, kilowatt hour (kWh) & cost of electricity.	15–25	
9. ELECTRICITY & MAGNETISM: Electric circuits • Solve problems involving current, potential difference (voltage) and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors). • Explain the term internal resistance. • Solve circuit problems using $\varepsilon = V_{load} + V_{int\ resistance}$ or $\varepsilon = IR_{ext} + Ir$. • Solve problems, with internal resistance, for circuits containing arrangements of resistors in series and in parallel (maximum four resistors).		
10. ELECTRICITY & MAGNETISM: Electrical machines (generators, motors) • Energy conversion in generators & use principle of electromagnetic induction to explain how they work. • Examples of uses of AC & DC generators & functions of components. • Energy conversion in motors & use motor effect to explain how they work. • Explain functions of components of motors & give examples of uses of motors. • State the advantages of alternating current. • Sketch graphs of voltage vs time and current vs time for an AC circuit. • Solve problems using $I_{rms} = \frac{I_{max}}{\sqrt{2}}$, $V_{rms} = \frac{V_{max}}{\sqrt{2}}$, $P_{ave} = I^2_{rms}R$, $P_{ave} = \frac{V^2_{rms}}{R}$, • $P_{ave} = I_{rms}V_{rms} = ½ I_{max}V_{max}$ (for a purely resistive circuit).	10–20	
11. MATTER & MATERIALS: Optical phenomena and properties of materials • Describe the photoelectric effect and state its significance. • Define threshold frequency, f_o and the work function, W_o. • Perform calculations using the photo-electric equation: $E = W_o + E_{kmax}$, where $E = hf$ and $W_o = hf_o$ and $E_{kmax} = ½ m(v_{max})^2$ • Explain the effect of intensity and frequency on the photo-electric effect. • Explain the formation of atomic spectra by referring to energy transition. • Explain the difference between of atomic absorption and emission spectra.	10–15	15
TOTAL OF PAPER	**150**	**150**

GRADE 12 **SEPTEMBER EXAMINATION (PAPER 2: 150 MARKS)**

KNOWLEDGE AREA (KA) & Topic (The numbers in front of the KA and topic are the numbers in the annual teaching plan)	**Approximate mark per topic**	**Approximate mark per KA**
4. MATTER & MATERIALS: Intermolecular forces (From grade 11) • Intermolecular & interatomic forces (chemical bonds). • Different intermolecular forces: ion-dipole, ion-induced dipole, dipole-dipole, dipole-induced dipole, induced dipole, H bonds. • Intermolecular forces and density, boiling point, melting point. • Particle kinetic energy and temperature. • The chemistry of water.	5–10	48
3. MATTER & MATERIALS: Organic molecules • Define the terms organic molecules, functional group, hydrocarbon, homologous series, saturated, unsaturated and structural isomer. • Write condensed, structural & molecular formulae (up to 8 C atoms, 1 functional group per molecule) for alkanes (no rings), alkenes (no rings), alkynes, haloalkanes (no rings), alcohols, carboxylic acids, esters, aldehydes & ketones • Write the IUPAC name when given the structural or condensed structural formula for compounds from the above ‘homologous series’ (one functional group per compound, max. two functional groups for haloalkanes). • Identify alkyl substituents (methyl- and ethyl-); max. THREE alkyl substituents. • Identify compounds that are saturated, unsaturated & are structural isomers (only chain isomers, positional isomers and functional isomers). • Physical properties: Explain the relationship between boiling point / melting point / vapour pressure (for any of above compounds) and strength of IMF, type of functional groups, chain length and branched chains. • Oxidation of alkanes: State use of alkanes as fuels & write an equation for the combustion of an alkane in excess oxygen. • Esterification: Write an equation & reaction conditions for the formation of an ester and name the alcohol and carboxylic acid used and the ester formed. • Identify reactions as elimination, substitution or addition. • Write equations and reaction conditions for the following addition reactions of alkenes: hydrohalogenation, halogenation, hydration, hydrogenation • Write equations and reaction conditions for elimination reactions: dehydrohalogenation of haloalkanes, dehydration of alcohols & cracking of alkanes • Write equations and reaction conditions for substitution reactions: hydrolysis of haloalkanes, reactions of HX (X = Cℓ , Br) with alcohols to produce haloalkanes, halogenation of alkanes • Plastics & polymers: Polymer, macromolecule, chain, monomer, functional group. • Polymerization of ethene to form polythene - equation & industrial uses. • Distinguish between addition & condensation polymers (polyesters).	35–40	

GRADE 12 SEPTEMBER EXAMINATION (PAPER 2: 150 MARKS)/Continue ...

13. CHEMICAL CHANGE: Representing chemical change (From grade 10) • Balanced chemical equations	These topics are included in the ones below.	84
8. CHEMICAL CHANGE: Quantitative aspects of chemical change (From grade 11) • Molar volume of gases; 1 mole of gas occupies 22,4 dm^3 at 0°C (273 K) and 1 atmosphere (101,3 kPa) pressure. • Volume relationships for gases under the same conditions of temperature and pressure (volume related to number of particles). • Concentration of solutions; calculate molar concentration of solutions. • Stoichiometric calculations including limiting reagents. • Calculate percentage yield of a chemical reaction. • Determine empirical formula and molecular formula. • Determine percentage purity or percentage composition. • Stoichiometric calculations with explosions as reactions e.g. • $2NH_4NO_3 \rightarrow 2N_2(g) + 4H_2O(g) + O_2(g)$ • $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ • Stoichiometric calculations using reaction in airbags (sodium azide): $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$		
12. CHEMICAL CHANGE: Energy & chemical change (from grade 11) • Enthalpy and its relationship to heat of reaction. • Exothermic and endothermic reactions. • Potential energy graphs for exothermic and endothermic reactions with and without catalysts. • Activation energy.		
6. CHEMICAL CHANGE: Rate and extent of reaction • Explain what is meant by reaction rate & list factors which affect reaction rate. • Explain in terms of collision theory how various factors affect the rate. • Write down experimental techniques for measuring the rate of a given reaction. • Define the term catalyst and explain how a catalyst increases reaction rate. • Interpret graphs of distribution of molecular energies to explain how a catalyst & temperature affect rate.	15-25	
7. CHEMICAL CHANGE: Chemical equilibrium • Explain: open & closed systems; reversible reactions; dynamic equilibrium • List the factors which influence the position of an equilibrium. • State Le Chatelier's principle and use it to explain changes in equilibria. • Interpret simple graphs of equilibrium. • Explain the use of rate & equilibrium principles in the Haber & Contact process. • List the factors which influence the value of the equilibrium constant K_c. • Write an expression for the equilibrium constant from a given equation. • Perform calculations based on K_c values and • Explain the significance of high and low values of the equilibrium constant.	15-25	
8. CHEMICAL CHANGE: Acids and bases • Define acids and bases according to Arrhenius and Lowry-Brønsted. • Distinguish between strong and weak acids/bases with examples. • Distinguish between concentrated and dilute acids/bases. • Identify conjugate acid-base pairs for given compounds. • Write neutralisation reactions of common laboratory acids and bases. • Perform calculations based on titration reactions & motivate choice of indicator. • Determine the approximate pH of salts in salt hydrolysis. • Explain the pH scale and calculate pH values of strong acids and strong bases. • Define the concept of K_w and explain the auto-ionisation of water. • Compare the K_a and K_b values of strong and weak acids and bases. • Compare strong and weak acids by looking at pH, conductivity & reaction rate.	15-25	
12. CHEMICAL CHANGE: Electrochemical reactions • Oxidation & reduction in terms of electron transfer & oxidation numbers. • Oxidising & reducing agents in terms of oxidation and reduction. • Anode and cathode in terms of oxidation and reduction. • Define a galvanic cell in terms of self-sustaining electrode reactions i.e. conversion of chemical energy to electrical energy. • Function of salt bridge, movement of ions, direction of electron flow in external circuit, half-reactions at each electrode & the overall cell reaction. Predict in which half-cell oxidation / reduction takes place. • Use cell notation or diagrams to represent a galvanic cell. • Calculate emf for a galvanic cell. V_{cell} decreases as [product ions] increases and [reactant ions] decreases. When equilibrium is reached, V_{cell} = 0 (the cell is 'flat'). • Define electrolytic cells: electrode reactions are sustained by a supply of electrical energy i.e. electrical energy converted to chemical energy. • Give and explain the relationship between current and the rate of the reaction. • Use half-reactions, cell reactions & schematic diagrams to describe the following electrolytic cells: decomposition of $CuC\ell_2$; electroplating (e.g. the refining of copper); chlor-alkali industry; recovery of aluminium metal • Describe risks to the environment of the chloroalkali-industry & recovery of Aℓ.	20-30	
13. CHEMICAL INDUSTRY: Fertiliser industry (N, P, K) • For plants: 3 non-mineral nutrients (C, H & O) & 3 primary nutrients (N, P & K). • Explain why fertilisers are needed & explain the function of N, P and K. • Interpret the N:P:K fertiliser ratio and perform calculations based on the ratio. • Processes in fertiliser industry: N_2 - fractional distillation of air; H_2 - from coal & steam; Haber process; Ostwald process; Contact process; NH_4NO_3; $(NH_4)_2SO_4$ • Evaluate the use of inorganic fertilisers on humans and the environment. • Define eutrophication and discuss alternatives to inorganic fertilisers.	12-20	18
TOTAL OF PAPER	**150**	**150**