PHYSICAL SCIENCES (Updated March 2014)

A. MEANS OF ASSESSMENT

Paper 1	3 hours	200 marks (scaled to 150 marks)
Paper 2	3 hours	200 marks (scaled to 150 marks)

School Based Assessment (SBA) 100 marks

400 marks

B. REQUIREMENTS

1. Examination

- Assessment tasks and questions will be based on the Subject Assessment Syllabus as outlined in Section E of this document.
- There will be two examination papers that will be written on different days
- A variety of questioning styles will be employed in the final examination with a maximum of 10% of the marks being in the multiple choice format.

WEIGHTING OF KNOWLEDGE AREAS

Table 1 – Physical Sciences Paper I (Physics)

Content Areas	**Approximate Marks (± 10 marks)**	**Approximate % (± 5%)**
Kinematics (Motion in 1D)	50	25
Newton's Laws and Applications of Newton's Laws	30	15
Momentum, Impulse, Work, Energy and Power	30	15
Gravitational and Electric Fields	20	10
Electric Circuits	30	15
Electrodynamics	24	12
Photons and Electrons	16	8

Table 2 – Physical Sciences Paper II (Chemistry)

Content Areas	**Approximate Marks (± 10 marks)**	**Approximate % (± 5%)**
Quantitative Chemistry	20	10
Chemical Bonding	20	10
Energy Change & Rates of Reactions	20	10
Chemical Equilibrium	30	15
Acids and Bases	30	15
Electrochemistry	40	20
Organic	40	20

Table 3.1 – Weighting of Examination according to Taxonomy of Cognitive Levels

Level	Description	Paper I Physics (%)	Paper II Chemistry (%)
1	Knowledge and Recall	15	15
2	Comprehensions and Routine Exercises	35	40
3	Application and Analysis	40	35
4	Synthesis and Evaluation	10	10

Information Pamphlet (Data Sheet)
Included with each of the Question Papers is a booklet containing the following information: Formulae and Equations, Physical Constants, Standard Electrode Potentials and Half-Reactions & the Periodic Table of Elements including electronegativity values.

N.B. Formulae and equations could be included for two reasons:

(a) To be used in the numerical calculation of physical quantities.

(b) To illustrate, in symbolic form, a scientific law or principle that should be known and applied verbally in the answer to a question.

Table 3.2
PHYSICAL SCIENCES ASSESSMENT TAXONOMY

LEVEL	COGNITIVE LEVEL	EXPLANATION	EXAMPLES IN PHYSICAL SCIENCES	ACTION VERBS
4	EVALUATION	The ability to judge the value of material (statement, research report) for a given purpose. The judgments are to be based on definite criteria, which may be internal (organisation) or external (relevance to the purpose).	• Has the experiment been successful in enabling you to decide on the truth of your hypothesis? • From these results, judge the adequacy with which conclusions are supported by data. • Make judgements on the suitability of experimental procedure to test a certain hypothesis. • Consider the arguments for and against using solar, nuclear and fossil fuels for our energy requirements and make judgements. • Makes choices based on reasoned arguments. • When blowing up a balloon John reports that both the volume and pressure increase. He states that pressure is proportional to volume. Discuss the validity of his conclusion. • Recognises subjectivity.	Justify, appraise, evaluate, judge *x* according to given criteria. Which option would be better/preferable to party *y*? Decide, recommend, convince, select, discriminate, support, conclude, critique.
4	SYNTHESIS	The ability to put parts together to form a new whole. This may involve the production of a unique communication, a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information). Learning outcomes in this area stress creative behaviours, with major emphasis on the formulation of new patterns or structure.	• Propose a plan for an experiment. • Design a 6V battery with a capacity of 40 Ah and with low internal resistance. • What conclusion can be drawn from these results? • What general advice would you give motorists about 'following distance' when travelling at different speeds? • Rearrange the equation $hf = W_f + \frac{1}{2} mv^2$ to obtain an expression which has h, W_f, or v as its subject.	Design, construct, develop, formulate, imagine, create, change, combine, integrate, modify, rearrange, substitute, plan, invent, compose, formulate, prepare, generalise, rewrite, compile, reconstruct, generate.
3	ANALYSIS	The ability to break down material into its component parts. Identifying parts, analysis of relationships between parts, recognition of the organisational principles involved.	• Describe ways in which you could improve the reliability of your results. • Circle any anomalous points on the graph and suggest an explanation for any anomaly. • Examine the graph to determine the relationship between the two variables. • Given the colours of the halogens, observe that the colour gets darker the further down in Group 17 of the Periodic Table that the halogen is situated. • The actual value for the Molar Latent Heat of Vapourisation of water is 40,7 $kJmol^{-1}$. What do you think are the most important reasons for your result not being accurate? Explain.	Differentiate, compare/contrast, distinguish *x* from *y*, how does *x* affect or relate to *y*? why? how? What piece of *x* is missing/needed? Analyse, separate, order, connect, classify, arrange, divide, select, infer, break down, diagram, illustrate, identify, outline, relate

3	**APPLICATION**	The ability to use learned material in new and concrete situations. Applying rules, methods, concepts, principles, laws, and theories.	• Apply Le Chatelier's principle to predict the colour change if sodium chloride is added to a particular equilibrium mixture. • Show by calculation that the collision is inelastic. (i.e. two step calculations) • Draw a labelled free body force diagram of the car during the braking process. Ignore wind resistance. • From the velocity-time graph, plot a corresponding displacement-time graph. • Write down the structural formula of the acid that could be used to combine with an alcohol in the synthesis of $CH_3CH_2CH_2CO_2CH_2CH_3$. • Ethanol and propane have nearly the same number of electrons. Explain why ethanol has a higher boiling point than propane. • Use the Standard Redox Table to determine the reaction between SO_2 and $KMnO_4$	How would you show, make use of, modify, demonstrate, solve, or apply *x* to conditions *y*? apply, calculate, illustrate, change.
2	**COMPREHENSION**	The ability to grasp the meaning of material. Translating material from one form to another (words to numbers), interpreting material (explaining or summarising), estimating trends (predicting consequences or effects).	• Use the graph and read off the pressure at a time of 10 seconds. • Explain why an increase in pressure increases rate of a gaseous chemical reaction. • Calculate the current if the voltage is 2 V and the resistance is 4 Ω. (i.e. 1 step calculation) • Write a balanced equation for the complete combustion of octane, C_8H_{18}. • Identify a dependent variable that you could measure to follow the rate of a given reaction. • What is the relationship between inter-molecular force strength and boiling point? • What does a positive E^0 value indicate about the reaction? • Describe the observation that can be made when bromine reacts with ethane.	Explain, predict, interpret, infer, summarise, convert, translate, give example, account for, paraphrase *x*, describe, associate, distinguish, estimate, extend, comprehend, generalise, give example, rewrite.
1	**RECALL**	The learner recalls and remembers facts, low cognitive demand.	• Name the instrument used to measure current. • State the law of conservation of mechanical energy. • Define momentum. • Label the parts indicated on this diagram of an electric motor. • Define Standard Electrode Potential. • Write down the **formula** of the three main compounds found in NPK fertiliser. • Identify and name the functional group in ethanol.	List, define, tell, state, identify, show, know, label, collect, select, reproduce, match, recognise, examine, tabulate, quote, name

RECORDING AND REPORTING

Table 4
Assessment tasks are reported against a seven point rating scale:

RATING CODE	RATING	MARKS %
7	Outstanding achievement	80 – 100
6	Meritorious achievement	70 – 79
5	Substantial achievement	60 – 69
4	Adequate achievement	50 – 59
3	Moderate achievement	40 – 49
2	Elementary achievement	30 – 39
1	Not achieved	0 – 29

2. School Based Assessment (SBA)

School based assessment comprises 25% of the total assessment for the National Senior Certificate. The minimum requirements for the school-based component of the National Senior Certificate assessment are outlined in Table 5. Where schools are able to do more than the minimum requirements then the learners may select their best work for the learner file. However, where there is a choice, the tasks should be of a comparable standard.

All schools must make available the SBA evidence of all learners should it be required by IEB or Umalusi.

These Subject Assessment Guidelines must be read in conjunction with the IEB Manual for the Moderation of School Based Assessment (2011) available at www.ieb.co.za.

Table 5: SBA REQUIREMENTS FOR GRADE 12

Task	**Percentages**
2 Practical Investigations (1 Physics Focus; 1 Chemistry Focus)	2 × 20% = 40%
Alternate Assessment or Experiment	10%
Controlled Test (Physics Focus) Controlled Test (Chemistry Focus) *N.B. Mid-year examinations may be used*	2 × 10% = 20%
Preliminary Examinations	2 × 15% = 30%
TOTAL	**100%**

Controlled Tests and Examinations

Controlled tests (minimum 40 minutes) and examinations are written under controlled conditions within a specified period of time. Questions in tests and examinations should assess performance at different cognitive levels across all the Topics.

Practical Investigations and the Alternate Assessment

Learners need to spend a minimum of 2 hours on each of the practical investigations and a minimum of 1 hour on the Alternate Assessment. There needs to be contact time between the learners and the teacher to facilitate guidance, support and monitoring of the achievement of specific targets. This contact time should be scheduled at mutually agreed intervals. These interactions create opportunities for teachers to:

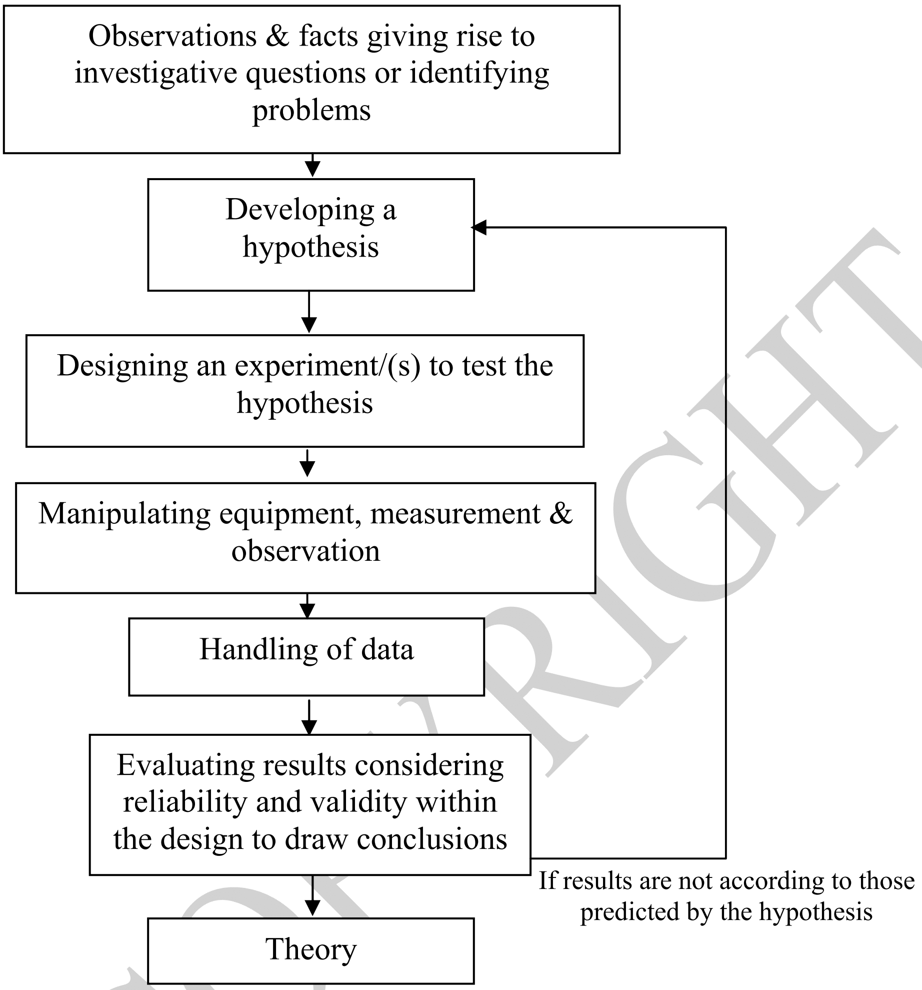
- check for plagiarism (for example by using oral questioning)
- carry out formative assessment
- monitor progress

The teacher should guard against marking the task at these times, but should question the learner about the project and respond to queries initiated by the learner. Marking occurs once, only when the task is finally submitted.

Practical investigations

The new FET focuses on teaching and assessing in an investigative approach. The motivation for teaching and assessing this type of approach is that it has the potential to reflect what life is about. The investigative approach not only teaches skills essential to science but skills essential for living in a modern world. But what is an investigative approach? What are the components that make up an investigation in the 'real' world? What skills, understanding and mental processing are required to carry out a successful investigation?

A very simplified perspective of the investigative approach is represented in the flow chart which follows:



One way to create an opportunity to proceed through an investigation is to identify a science problem to be solved. In trying to solve a science problem one will certainly need to proceed through an investigative approach. In addition, one will find that it is impossible to be restricted by purely an experimental approach. Problem solving in science requires mastering basic investigative skills, applying scientific concepts appropriately.

Investigations do not, however, need to be restricted to a complex problem that needs to be solved. It is possible to combine a number of traditional one lesson experiments to produce the same learning objectives as a large single focused task. Where smaller tasks are compiled together it is advisable to have a central theme to facilitate continuity, and it is also important that the combined skills assessed across all these tasks together represent the objectives achieved by a more open-ended larger task. In other words the smaller tasks must not all assess the same things.

The investigations are expected to take a minimum of 2 hours.

The following is suggested as a guide to what should be assessed in a balanced way (according to cognitive levels) across an investigation.

1. Developing a hypothesis. This could include:
    - formulating a question which can be investigated.
    - combining scientific ideas with observations or recorded facts.
    - making predictions based on available knowledge and observations.
    - writing a statement of the hypothesis.

2. Manipulation of equipment, measurement and observations. This could include:
    - correct choice of equipment.
    - ability to read scales accurately.
    - safe use of equipment.
    - meaningful observations.

3. Planning and designing. This could include:
    - identifying variables to be measured and controlled.
    - organising activities in an appropriate sequence.
    - recognising whether or not an experiment is valid. (Will the results answer the investigative question?)
    - recognising the importance of the reliability of results and planning accordingly. (Are the sample size and number of readings sufficient?)

4. Presentation of data. This could include:
    - tabulating.
    - graphing.
    - use of data loggers and other software.

5. Analysing, concluding and evaluating. This could include:
   - weighing advantages and disadvantages.
   - drawing appropriate conclusions that address the hypothesis or questions.
   - Making/evaluating general conclusions that go beyond the experimental or given conditions.
   - analysing problems to determine the relevant relationships, concepts, and problem-solving steps.

6. Communicating and presenting information. This could include:
   - a model.
   - a role play, song, dance, speech or presentation.
   - a poster.
   - a written report.

Alternate Assessment

Suggestions for Alternate Assessment tasks:

1. **Debate, discussion, short essay, e.g. on ethical issues in science**

   The website www.peep.ac.uk has many ideas to engage learners in discussions and critical thinking about the impact of science on everyday life,
   e.g. Alternative fuels
   Provide the learner with 2 or 3 short concise articles on alternative fuels, a graph of the projected national estimates of fuel consumption for the next 10 years.

   Pose the problem, e.g.
   Choosing one of the alternative fuels as the main fuel to be used in South Africa in 10 years' time, draw up a consequence chart to show how this will affect businesses, the general public, transport operators and the government.

2. **Translation task**

   Given an article from a scientific magazine, journal, newspaper or video clip, analyse, discuss and/or answer questions and solve problems related to it.

3. **Experiment**

   An experiment is a less demanding practical activity than a practical investigation in the following ways:
   - The investigative question is posed for the learners.
   - The procedure (method) may be stated as a series of instructions to the learners.
   - The activity is set to take a minimum of 1 hour (and a maximum of 2 hours).

   The recording of results, analysis and manipulation of data to draw conclusions remain as specified for a practical investigation.
   The cognitive demands of this task should include all levels of performance (Level 1 – 4).

4. Research project

A research project is a report that weighs up evidence about a scientific question where a decision needs to be made. Generally, the topic should focus on an area where the science is not certain or where conflicting evidence is available.

The following are examples of typical topics involving questions about **decision making using scientific information:**

- Should government introduce laws which make it an offence to drive a vehicle which emits visible exhaust fumes?
- Do mobile phones cause brain damage? If so, what should be done about it?
- Are pharmaceutical companies reluctant to research dichloro-acetate as an alternative cure for cancer patients and what should be done?
- Why has it taken so long for hybridised cars to reach the market? Is it deliberate and if so, could companies face legal action?
- How has the introduction of artificial fertilisers improved the quality of human life in South Africa?
- Is it time for renewable energy to stop being the alternative and start becoming the mainstream, eventually transforming our lives? What is the next big energy source?
- What is best way to disinfect a swimming pool?
- Will bio-fuel help save our world from global warming? Should it be encouraged? If so how?

A research project is similar to an experimental investigation. The essential difference is the source of the data or information. Both the experimental investigation and the research project will usually include some (or all) of the following steps:

- identify a problem to be solved
- formulate a 'research' question (or collection of questions) to be investigated
- formulate a hypothesis to be tested (that is generated from the investigative question)
- collect data/information (books, magazines, journals, Internet, experts, …) and record these references as a bibliography in the report
- select and arrange relevant data
- evaluate the data/information
- draw conclusions

During research tasks, learners should be encouraged to obtain information from other resources. In order to avoid plagiarism, they must be taught explicitly how to reference correctly. Information obtained from other sources **must** be synthesised and re-written in the learner's own words (unless it is given in quotation marks). The reference used **must** be cited in the text and a reference list **must** be included. Teachers are encouraged to allocate marks for correct citation and for producing a suitable reference list. Since teachers have to sign a declaration (Appendix B) which states that they have monitored work for plagiarism, it is incumbent upon them to make sure that learners are properly instructed in referencing and that they do check for plagiarism.

This task should be marked on how the learners represent the information they have obtained and on what they do with this information. It is **NOT** only about putting other people's information in their own words. It is, more importantly, about the ideas and beliefs which the learner holds as a result of the research and information he or she has obtained.

Table 6: An example of the Formal Programme of Assessment

SCHOOL BASED ASSESSMENT (25%)			**EXTERNAL ASSESSMENT (75%)**
Practical investigation Physics Focus	Practical investigation Chemistry Focus	Alternate Assessment /Experiment	Final Examinations
Midyear Examinations or two Controlled Tests		Preliminary Examinations	

Additional explanatory comments

- Table 6 describes the Formal Programme of Assessment and includes only summative assessment. However, formative assessment is integral to teaching and learning. It should take place on a daily basis. Daily assessment can be informal or formal and formative or summative (recorded). In this process teachers will set many more tasks than are required for the SBA as described in Table 6 above. This is to the advantage of their learners. However, teachers may only submit the tasks requested in Table 5 and only these tasks can be taken into account when teachers calculate the SBA mark.
- Teachers are encouraged to set metacognitive tasks in the SBA component, e.g. ask candidates to set a test, prepare marking guidelines and analyse answers for misconceptions.
- Learner Files should be transferred with a learner from one school to another.
- The final SBA mark should be reported as a percentage.

Moderation of the assessment tasks in the Programme of Assessment

Table 7

Level	Moderation Requirements
School	The Formal Programme of Assessment should be monitored at the beginning of the year to ensure compliance with requirements. Each task which is to be used as part of the Formal Programme of Assessment should be moderated before learners attempt the task. Teacher and learner files should be monitored for compliance before submission for cluster moderation. Learners and teachers must sign a letter of authenticity to be included in the learner file. The principal signs a letter, to be included in the teacher file, stating that appropriate moderation has taken place at school level.
Cluster	Teachers are required to attend two cluster meetings per year, the first before 15 March and the second by 15 September. The Formal Programme of Assessment should be monitored at the first meeting to ensure compliance with requirements and proposed tasks discussed to ensure they are of an appropriate standard. No formal moderation of files will take place at the second meeting. However, it is suggested that the teachers discuss the tasks that they have set, the standard of those tasks and how they will be marked. The second meeting is also an opportunity to share resources so that schools in a cluster can maintain a common standard.
IEB	Following the second cluster meeting, some schools/subjects may be regionally moderated by a moderator appointed by the IEB. A school which has been regionally moderated may not need to send portfolios for National moderation, unless either a particular problem is identified or the files are identified as exemplary. During the December National Senior Certificate marking session a moderating committee, appointed by the IEB, under the leadership of a National Moderator, carries out the following checks: • monitors the teacher file and the sample of learner files, prescribed by the IEB, for compliance, from each examination centre. • monitors the standard of the SBA tasks. • moderates a sample of learner tasks (the standard of the marking is checked) to ensure comparable standards across centres across the IEB. • completes a report on the SBA work of each centre. A copy of this report is returned to the centre. • recommends mark changes to the IEB if the marks allocated for school based assessment at a particular centre do not reflect an appropriate standard of performance.

Learner's File

- Each learner must be able to produce all the work as listed in Table 5. This work is evidence of the learner's performance and justification for the marks the learner has been allocated for SBA. This work must be collected together in some convenient format that is neither expensive nor bulky. A flat folder or file or even a set of 'treasury tags' to bind the sheets together, will suffice. This folder of work constitutes the learner's file and must be available for moderation if called for by the IEB.
- For performances or the production of models, or any other situation where it is not possible to keep the products of the task, the task assessment sheet should be retained in the file. The assessment sheet in such cases should list the criteria against which the learner was assessed and give details of the performance (marks).
- All the tasks in the file must be in the same sequence as the task sheets in the teacher's file for ease of moderation.
- The first page (Appendix B) in each file must give the centre number, the learner's examination number and include an index of tasks and the mark allocation for the tasks.
- The declaration of authenticity (see Appendix B) must be completed and included as the second page of the file.

Teacher's File

- Each school must submit one subject file with the compulsory SBA.
- The teacher's file must include all summative assessment task sheets or question papers with marking schemes, rubrics and marking guidelines (tests and examinations), as applicable.
- The teacher's file must also include a mark sheet to provide evidence of all the individual marks that contribute to each component for each candidate described in Table 5. The final SBA mark should also be given as a percentage. The documentation must make it clear how the final percentage was determined.

Learner Absence

- Learners should be given an opportunity to make up missed tasks. If necessary an equivalent task can be done.
- An authentic reason in writing, i.e. a doctor's letter, should be produced if a learner misses an SBA task.

C. INTERPRETATION OF REQUIREMENTS

The purpose of the Assessment Syllabus is to assist IEB teachers in reaching a common understanding of the scope of the Curriculum and Assessment Standards (CAPS). The Assessment Syllabus is to make explicit the scaffolding of concepts and the enabling of learning over the grade 11 and grade 12 years. It is all the grade 11 and grade 12 content that is being examined at the end of the grade 12 year. The Assessment Syllabus clearly enables assessment and supports teachers, assessors and moderators in the Physical Sciences.

EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES (PHYSICS)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9{,}8\ \text{m.s}^{-2}$
Speed of light in a vacuum	c	$3{,}0 \times 10^{8}\ \text{m.s}^{-1}$
Universal gravitational constant	G	$6{,}7 \times 10^{-11}\ \text{N.m}^{2}.\text{kg}^{-2}$
Coulomb's constant	k	$9{,}0 \times 10^{9}\ \text{N.m}^{2}.\text{C}^{-2}$
Magnitude of charge on electron	e	$1{,}6 \times 10^{-19}\ \text{C}$
Mass of an electron	m_e	$9{,}1 \times 10^{-31}\ \text{kg}$
Planck's constant	h	$6{,}6 \times 10^{-34}\ \text{J.s}$
1 electron volt	eV	$1{,}6 \times 10^{-19}\ \text{J}$

TABLE 2 PHYSICS FORMULAE

MOTION

$v = u + at$ **or** $v_f = v_i + a\Delta t$	$s = \left(\frac{v+u}{2}\right)t$ **or** $\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$
$v^2 = u^2 + 2as$ **or** $v_f{}^2 = v_i{}^2 + 2a\Delta x$	$s = ut + \frac{1}{2}at^2$ **or** $\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$

FORCE AND MOMENTUM

$F_{net} = ma$	$F_{net} = \frac{\Delta p}{\Delta t}$ **or** $F_{net}\Delta t = m\Delta v$	$\Delta p = mv - mu$ **or** $\Delta p = mv_f - mv_i$
$p = mv$	$w = F_g = mg$	$F_f^{\max} = \mu F_N$

WORK, ENERGY AND POWER

$W = Fs$ **or** $W = F\Delta x$ **or** $W = F\Delta x \cos\theta$	$P = \frac{W}{t}$	$P = Fv$

$E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_K$	$efficiency = \frac{power_{out}}{power_{in}}$

GRAVITATIONAL AND ELECTRIC FIELDS

<table>
<tr><td colspan="3">$F = G\frac{m_1 m_2}{r^2}$</td><td colspan="3">$g = G\frac{M}{r^2}$</td></tr>
<tr><td colspan="2">$F = k\frac{q_1 q_2}{r^2}$</td><td colspan="2">$E = \frac{F}{q}$</td><td colspan="2">$E = \frac{kQ}{r^2}$</td></tr>
</table>

ELECTRIC CIRCUITS

<table>
<tr><td>$I = \frac{Q}{t}$</td><td>$V = \frac{W}{q}$</td></tr>
<tr><td>$R = \frac{V}{I}$</td><td>$emf = I(R_{ext} + r)$</td></tr>
<tr><td>$R_S = R_1 + R_2 + ...$</td><td>$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + ...$</td></tr>
<tr><td colspan="2">$P = \frac{W}{t}$ **or** $W = Pt$</td></tr>
<tr><td colspan="2">$W = VIt$ **or** $W = I^2 Rt$ **or** $W = \frac{V^2}{R}t$</td></tr>
<tr><td colspan="2">$P = VI$ **or** $P = I^2 R$ **or** $P = \frac{V^2}{R}$</td></tr>
</table>

ELECTRODYNAMICS

<table>
<tr><td>$\Phi = BA\cos\theta$</td><td>$emf = -\frac{N\Delta\Phi}{\Delta t}$</td></tr>
<tr><td>$V_p I_p = V_s I_s$</td><td>$\frac{N_s}{N_p} = \frac{V_s}{V_p}$</td></tr>
</table>

PHOTONS AND ELECTRONS

<table>
<tr><td colspan="3">$c = f\lambda$</td><td colspan="3">$E = hf$ **or** $E = \frac{hc}{\lambda}$</td></tr>
<tr><td colspan="2">$E = W_0 + E_{K(max)}$</td><td colspan="2">$W_0 = hf_0$</td><td colspan="2">$E_{K(max)} = \frac{1}{2}mv_{max}^{\ 2}$</td></tr>
</table>

EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES (CHEMISTRY)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Magnitude of charge on electron	e	$1,6 \times 10^{-19}$ C
Mass of an electron	m_e	$9,1 \times 10^{-31}$ kg
Standard pressure	p^θ	$1,01 \times 10^5$ Pa
Molar gas volume at STP	V_m	$22,4$ dm^3.mol^{-1}
Standard temperature	T^θ	273 K
Avogadro's constant	N_A	$6,02 \times 10^{23}$ mol^{-1}
Faraday’s constant	F	96 500 C.mol^{-1}

TABLE 2 CHEMISTRY FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$	$n = \frac{V}{V_m}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$Q = It$	$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ $E^\theta_{cell} = E^\theta_{oxidising\,agent} - E^\theta_{reducing\,agent}$	

TABLE 3 PERIODIC TABLE

Atomic number (Z) 1 2.1 **H** 1 **Electronegativity**

Relative atomic mass

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 2.1 **H** 1																	2 **He** 4
2	3 1.0 **Li** 7	4 1.5 **Be** 9											5 2.0 **B** 10.8	6 2.5 **C** 12	7 3.0 **N** 14	8 3.5 **O** 16	9 4.0 **F** 19	10 **Ne** 20
3	11 0.9 **Na** 23	12 1.2 **Mg** 24.3											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
4	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** 65.4	31 1.6 **Ga** 70	32 1.8 **Ge** 72.6	33 2.0 **As** 75	34 2.4 **Se** 79	35 2.8 **Br** 80	36 **Kr** 84
5	37 0.8 **Rb** 85.5	38 1.0 **Sr** 88	39 1.2 **Y** 89	40 1.4 **Zr** 91	41 1.6 **Nb** 93	42 1.8 **Mo** 96	43 1.9 **Tc** 99	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** 121	52 2.1 **Te** 128	53 2.5 **I** 127	54 **Xe** 131
6	55 **Cs** 133	56 **Ba** 137.3		72 **Hf** 178.5	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 200.6	81 **Tℓ** 204.4	82 **Pb** 207	83 **Bi** 209	84 **Po** -	85 **At** -	86 **Rn** -
7	87 **Fr**	88 **Ra**																

57 **La**	58 **Ce**	59 **Pr**	60 **Nd**	61 **Pm**	62 **Sm**	63 **Eu**	64 **Gd**	65 **Tb**	66 **Dy**	67 **Ho**	68 **Er**	69 **Tm**	70 **Yb**	71 **Lu**
89 **Ac**	90 **Th**	91 **Pa**	92 **U**	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lw**

TABLE 4 STANDARD ELECTRODE POTENTIALS

Increasing oxidising ability

Increasing reducing ability

Half –reaction			E°/volt
$Li^+ + e^-$	$\rightleftharpoons$	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	-2.37
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	-1.66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	-1.18
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	-0.83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	-0.76
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	-0.74
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	-0.44
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	-0.40
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	-0.28
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	-0.25
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	-0.14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	-0.13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	-0.04
$2H^+ + 2e^-$	$\rightleftharpoons$	$H_2(g)$	0.00
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+0.14
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+0.15
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+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
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+0.54
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+0.68
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+0.77
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	Hg	+0.79
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+0.80
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+0.80
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+0.96
$Br_2 + 2e^-$	$\rightleftharpoons$	$2Br^-$	+1.09
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+1.20
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+1.21
$O_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+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
$Au^{3+} + 3e^-$	$\rightleftharpoons$	Au	+1.42
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+1.51
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1.77
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+2.87

D. ADMINISTRATIVE AND SUPPORT DOCUMENTATION

1. Appendix A: Task planning sheet
2. Appendix B: SBA Cover Sheet and Declaration of Authenticity
3. Appendix C: Sample moderation checklist
4. Appendix D: A suggestion for the letter from the principal
5. Appendix E: Summary mark sheet
6. Appendix F: Teacher Support Checklist (Not for moderation purposes)

1. APPENDIX A

NATIONAL SENIOR CERTIFICATE EXAMINATION

PHYSICAL SCIENCES

APPENDIX A

SAMPLE PHYSICAL SCIENCES TASK PLANNING SHEET

Title of Task		**Date**	
Content Knowledge			

	Place a cross in the appropriate box				
TASK TYPE:	Alternate Assessment /Experiment	Physics Practical Investigation	Chemistry Practical Investigation	Controlled Test	Examination

Question	**Topic(s) – please list**	**Cognitive level**			
		1	2	3	4
Total Actual Mark	▨				

Total maximum marks for the task							
Target % (see SAGs)							
Target Mark							
(Mark)-(Target)							

2. APPENDIX B: DECLARATION OF AUTHENTICITY

NATIONAL SENIOR CERTIFICATE EXAMINATION
PHYSICAL SCIENCES LEARNER FILE COVER SHEET
DECLARATION OF AUTHENTICITY

☐ **CENTRE NO.** ☐ **CANDIDATE'S NO.**

NAME OF CANDIDATE: ___________________________________

NAME OF TEACHER: _____________________________________

Component	Task	Date	Out of	Mark	%	Weight	Calc. Value
Investigations	1. Physics Practical					**20%**	
	2. Chemistry Practical					**20%**	
	3. Alternate Assessment/ Experiment					**10%**	
Test	1. Physics:					**10%**	
Test	2. Chemistry:					**10%**	
Examination	Paper I: Physics					**15%**	
Examination	Paper II: Chemistry					**15%**	
FINAL MARK						**100%**	

DECLARATION BY THE CANDIDATE:

I, ____ (print full names)

declare that all external sources used in my Learner File have been properly referenced and that the remaining work contained in this portfolio is my own original work. I understand that if this is found to be untrue, I am liable for disqualification from the National Senior Certificate.

Signed: ___________________________ Date: ___________________________
Candidate

DECLARATION BY THE CANDIDATE'S TEACHER:

I ____ (print name and title of teacher) at

____ (print name of school) declare that the work provided by this candidate has been monitored and checked for plagiarism.

Signed: ___________________________ Date: ___________________________
Teacher

3. APPENDIX C: SAMPLE MODERATION CHECKLIST FOR REGIONAL OR NATIONAL MODERATION

NATIONAL SENIOR CERTIFICATE EXAMINATION

PHYSICAL SCIENCES

SAMPLE MODERATION CHECKLIST FOR REGIONAL OR NATIONAL MODERATION

To be completed and returned to the school

Examination Centre Number: ________________ Date: ____________

Please present teacher portfolios in ring files or lever arch files. Please use dividers to separate sections and do not use plastic folders.

Records	***Yes***	***No***	***Comment (if required)***
Appendix D – letter from principal			
Every learner's Appendix B including learner declarations (1st page of learner file)			
Internal mark sheet including:			
Raw score for each task			
Percentage for each task			
Weighted total for each task			
Total of 7 weighted tasks			
Accurate aggregation of marks			
Internal mark sheets – alphabetical results and rank order (Appendix E)			
IEB mark sheets – alphabetical results and rank order			
Marks on all mark sheets correlate			
Moderation policy			

Tasks set and moderated according to requirements	***Task***	***Memo or rubric***	***Evidence of moderation***	***Appropriate standard***	***Analysis grid***
Physics investigation					▨
Chemistry investigation					▨
Alternative assessment					▨
Physics controlled test					▨
Chemistry controlled test					▨
Physics preliminary examination (must include Appendix A)					
Chemistry preliminary examination (must include Appendix A)					

Only if learner file have been requested

Learner files should be in flat files with dividers and no plastic folders and no question papers	***Yes***	***No***	***Comment (if required)***
List of learners requested by IEB			
Learner files supplied according to list from IEB			
Tasks marked in accordance with memorandum			
Appendix B correctly completed and transferred			

Additional comments (including descriptions of any tasks or questions of particular merit):

____

____

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Moderator's Signature: ______________________________ ***Date:*** ________________

4. APPENDIX D: A SUGGESTION FOR THE LETTER FROM THE PRINCIPAL

NATIONAL SENIOR CERTIFICATE EXAMINATION
PHYSICAL SCIENCES
A SUGGESTION FOR THE LETTER FROM THE PRINCIPAL

________ SCHOOL ________
________ ADDRESS ________
____
____

The IEB
P O Box 875
Highlands North
2037

Dear IEB Moderator

RE: SCHOOL BASED ASSESSMENT AND MODERATION OF PHYSICAL SCIENCES SBA IN GRADE 12

We certify that

teachers of the same subject have ensured that	Circle your response	
they have met regularly to reflect on and discuss issues of standardisation	YES	NO
the assessment tasks they have set learners are of the required standard	YES	NO
the memoranda they have used for marking are accurate and functional	YES	NO
the tasks learners have completed meet the criteria described in the IEB Subject Assessment Guidelines	YES	NO
marking is complete and of the appropriate standard	YES	NO
all administrative procedures have been correctly completed	YES	NO
all information on the 1st page of the portfolio (Appendix B) in each learner's file is complete and correct	YES	NO

______________________ ______________________
TEACHER PRINCIPAL

DATE: _______________ DATE: _______________

5. APPENDIX E: SAMPLE SUMMARY MARK SHEET

ieb
assessment matters

NATIONAL SENIOR CERTIFICATE EXAMINATION

PHYSICAL SCIENCES

Year	**Exam Number**	**Name**	**Physics Investigation**			**Chemistry Investigation**			**Alternative Task**			**Physics Test**			**Chemistry Test**			**Physics Prelim**			**Chemistry Prelim**			**SBA**
Total				**100**	**20**		**100**	**20**		**100**	**10**		**100**	**10**		**100**	**10**		**100**	**15**		**100**	**15**	**100**
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E. SUBJECT ASSESSMENT SYLLABUS

This document aims to specify the IEB Grade 12 examination objectives for 2014 onwards as precisely as possible.

It is recommended that both the grade 11 and grade 12 year are dedicated to preparing for this assessment syllabus.

Questions which test skills may be based on content which is unfamiliar to the candidate. In answering such questions, learners are required to use principles and concepts, which are within the curriculum and apply them in a logical, reasoned or deductive manner to a novel situation.

Implementation: Grade 11 in 2013, Grade 12 in 2014

A candidate should be able to:

I. PHYSICS

A. Kinematics (Motion in 1D)

1. Vectors

- Define a vector as *a physical quantity that has both magnitude and direction* and give examples
- Define a scalar quantity as *a physical quantity that has magnitude only* and give examples
- Define resultant vector as *the single vector which has the same effect as the original vectors acting together*
- Determine the resultant vector of any two vectors
- Determine two perpendicular components of any vector (e.g. force at an angle, weight on an inclined plane)

2. Displacement, Velocity and Acceleration

- Define position relative to a reference point and understand that position can be positive or negative
- Know that position is a vector quantity that points from the reference point as the origin
- Define distance *as the length of path travelled* and know that distance is a scalar quantity
- Define displacement *as a change in position*
- Know that displacement is a vector quantity that points from the initial to the final position
- Define speed *as the rate of change of distance* and know that speed is a scalar quantity
- Define velocity *as the rate of change of position or rate of displacement* and know that velocity is a vector quantity
- Distinguish between average velocity and instantaneous velocity
- Define acceleration *as the rate of change of velocity*

3. Vertical Projectile Motion in One Dimension (near the surface of the Earth in the absence of air resistance)

- Explain that projectiles fall freely with gravitational acceleration 'g'. Where g = 9,8 m.s^{-2} near the surface of the Earth
- Know that projectiles take the same time to reach their greatest height from the point of upward launch as the time they take to fall back to the point of launch

4. Graphs of Motion

For either horizontal motion or vertical motion with constant acceleration:

- Draw position vs time, velocity vs time and acceleration vs time graphs for one dimensional motion
- Interpret graphs of motion:
    - Determine the velocity of an object from the gradient of a position (or displacement) vs time graph
    - Determine the acceleration of an object from the gradient of a velocity vs time graph
    - Determine the displacement of an object by finding the area under a velocity vs time graph

5. Equations of Motion

- Use equations of motion to solve problems involving either horizontal motion or vertical motion with constant acceleration:

$v = u + at$	$v_f = v_i + a\Delta t$
$v^2 = u^2 + 2as$	
$s = ut + \frac{1}{2}at^2$	$v_i^2 = v_i^2 + 2a\Delta x$
$s = \left(\frac{u+v}{2}\right)t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$
	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$

Note: Both versions of the equations will be accepted. For the purpose of this document, u, v, a, t and s will be used

B. Newton's Laws and Application of Newton's Laws

1. Different Kinds of Forces: weight, normal force, frictional force, applied (push, pull) force, tension (strings or cables)

- Define weight F_g *as the gravitational force the Earth exerts on any object on or near its surface*
- Calculate weight using the expression $F_g = mg$ where g is the acceleration due to gravity. Near the surface of the earth the value is approximately 9,8 m.s^{-2}
- Define normal force, F_N, *as the perpendicular force exerted by a surface on an object in contact with it*
- Define frictional force due to a surface, F_f, *as the force that opposes the motion of an object* and acts parallel to the surface with which the object is in contact
- Explain what is meant by the maximum static friction
- Calculate the value of the maximum static frictional forces for objects at rest on horizontal and inclined planes using:

  $F_f^{\max} = \mu F_N$

  where μ is the coefficient of static friction
- Distinguish between static and kinetic friction forces

2. Force Diagrams, Free Body Diagrams

- Draw a labelled force diagram by representing the object(s) of interest with all the forces acting on it (them) drawn in as arrows. The forces must be named (e.g. Weight, normal, force A on B, friction, air resistance)
- Draw a free-body diagram by drawing the object of interest as a dot and all the forces acting on it drawn as arrows pointing away from the dot. The forces must be named (e.g. weight, normal, force A on B, friction, air resistance)
- Resolve two-dimensional forces into parallel (x) and perpendicular (y) components (e.g. the weight of an object with respect to an inclined plane)
- Calculate the resultant or net force in the x-direction as a vector sum of all the components in the x-direction and the resultant or net force in the y-direction as a vector sum of all the components in the y-direction

3. Newton's First, Second and Third laws

- State Newton's first law: *An object continues in a state of rest or uniform (moving with constant) velocity unless it is acted upon by a net or resultant force*
- Define inertia *as the property of an object that causes it to resist a change in its state of rest or uniform motion*
- State Newton's second law: *When a net force,* F_{net}*, is applied to an object of mass, m, it accelerates in the direction of the net force. The acceleration, a, is directly proportional to the net force and inversely proportional to the mass*
- Solve problems using
  $F_{net} = ma$
- Apply Newton's laws to a variety of equilibrium and non-equilibrium problems.
  (e.g. Discuss, using Newton's first law, why it is important to wear seatbelts)
  (e.g. Use Newton's second law to solve problems including an object moving on a horizontal/inclined plane (frictionless and rough), vertical motion (e.g. Rockets, hoisting masses etc.) and also two-body systems such as two masses joined by a light (negligible mass) string moving in a straight line either vertically or horizontally)
- State Newton's third law: *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 (e.g. for a donkey pulling a cart, for a book on a table)
- Demonstrate an understanding of the properties of action-reaction pairs (are equal in magnitude, act in opposite directions, act on different objects, occur simultaneously, act along the same line)

C. Momentum, Impulse, Work, Energy and Power

1. Momentum (1D)

- Define momentum as *the product of the mass and velocity of the object*
- State that momentum is a vector
- Calculate the momentum in one dimension of a moving object using $p = mv$

2. Newton's Second Law expressed in terms of Momentum

- State Newton's second law in terms of momentum: *The net force acting on an object is equal to the rate of change of momentum.* (Note: there are two acceptable statements of Newton's Second Law)
- Solve problems for constant mass using $F_{net} = \dfrac{\Delta p}{\Delta t}$

3. Conservation of Momentum and Elastic and Inelastic Collisions

- Explain that an isolated (or closed) system is one that has no net external force acting on it
- Explain (when working with isolated systems) what is meant by internal and external forces
- State the law of conservation of linear momentum: *The total linear momentum of an isolated system remains constant* (is conserved)
- Solve problems by applying the law of conservation of momentum to interactions of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention
- Define an elastic collision as *a collision in which both momentum and kinetic energy are conserved*
- Define an inelastic collision *as a collision in which only momentum is conserved*
- Identify elastic and inelastic collisions using calculations where necessary

4. Impulse

- Define impulse as the product of the net force and the contact time $impulse = F_{net}\Delta t$
- Know that impulse is a vector quantity
- Know that $F_{net}\Delta t$ is a change in momentum, i.e. $F_{net}\Delta t = \Delta p$
- Solve problems using $F_{net}\Delta t = \Delta p$
- Apply the concept of impulse in everyday life, e.g. airbags, catching a hard ball

5. WORK, ENERGY AND POWER

(a) Definition of Work

- Define the work done on an object by a force as *the product of the displacement and the component of the force parallel to the displacement*
- Solve problems using:
  $W = F.s \quad \left(or\ W = F\Delta x \quad or \quad W = F\Delta x \cos\theta\ is\ allowed \right)$
- Know that work is a scalar quantity and is measured in joules (J)

(b) Mechanical Energy

- Define gravitational potential energy as *the energy an object possesses due to its position relative to a reference point*
- Calculate the gravitational potential energy of an object using $E_p = mgh$
- Define kinetic energy as *the energy an object has as a result of the object's motion*
- Calculate the kinetic energy of an object using $E_K = \frac{1}{2}mv^2$
- Define mechanical energy as *the sum of gravitational potential and kinetic energy at a point*
- Use the equation: $E_M = E_p + E_K$
- State the law of conservation of energy as *the total energy in a system cannot be created nor destroyed; only transferred from one form to another*
- State the principle of conservation of mechanical energy: *In the absence of air resistance or any external forces, the mechanical energy of an object is constant*
- Apply the principle of conservation of mechanical energy and solve problems using:
  $\left(E_p + E_K\right)_i = \left(E_p + E_K\right)_f$

(c) Work – Energy Theorem

- State that the *work done by a net force on an object is equal to the change in the kinetic energy of the object* – the work-energy theorem
- Apply the work-energy theorem to objects on horizontal and inclined planes (frictionless and rough)
- Kinetic energy of a system is increased when F_{net} is in the same direction as s or Δx
- Kinetic energy of a system is decreased when F_{net} is in the opposite direction to s or Δx

(d) Conservation of Energy with External Forces and/or Resistive Forces Present

- Solve conservation of energy problems (with and without external forces and/or resistive forces present) by applying the law of conservation of energy

(e) Power

- Define power *as the rate at which work is done* or the *rate at which energy is transferred*
- State that the unit of power is the watt (W). One watt is defined as *the power when one joule of work is done in one second. (1 W = 1 J.s^{-1})*
- Calculate the power involved when work is done using $P = \frac{W}{t}$
- If a force causes an object to move at a constant velocity, calculate the power using $P = Fv$
- Define efficiency as *the ratio of output power to input power*
- Calculate percentage efficiency using $efficiency = \frac{power_{out}}{power_{in}} \times 100$

D. Gravitational and Electric Fields

1. Newton's Law of Universal Gravitation

- State Newton's Law of Universal Gravitation: *Every particle in the universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres*
- Use the equation for Newton's Law of Universal Gravitation to solve problems $F = G\frac{m_1 m_2}{r^2}$
- Define weight (F_g) *as the gravitational force the Earth exerts on any object on or near its surface*
- Calculate the acceleration due to gravity on any planet using the equation: $g = G\frac{M_{planet}}{\left(R_{planet}\right)^2}$
- Calculate the gravitational force on an object on other planets with different values of gravitational acceleration.
- Distinguish between mass and weight
- Know that the unit of weight is the newton (N) and that of mass is the kilogram (kg)

2. ELECTROSTATICS

(a) Coulomb's Law

- State Coulomb's law in words as *the force between two charges is directly proportional to the product of the charges and inversely proportional to the distance between the charges squared*
- Know Coulomb's law can be represented mathematically as $F = \frac{kq_1q_2}{r^2}$

  Solve problems using Coulomb's law to calculate the force between two charges

(b) Electric Fields

- 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 lines for various configurations of charges (point charges, two point charges, outside a charged hollow sphere, parallel plates)
- Define the magnitude of the electric field at a point *as the force per unit positive charge* $E = \frac{F}{q}$ where E and F are vectors
- Solve problems using $E = F / q$ (no parallel plates)
- Calculate the electric field strength at a point due to a point charge, using the equation $E = \frac{kQ}{r^2}$ to determine the contribution to the field due to each charge

  (Convention: *Q* represents the charge responsible for the electric field. *q* represents the charge experiencing the electric field)
- Determine the resultant electric field for a maximum of two charges

E. Electric Circuits

1. Ohm's Law

- Define potential difference as *the work done per unit positive charge* $V = \frac{W}{q}$
- Define current as *the rate of flow of charge* $I - \frac{q}{t}$
- Determine the relationship between current and potential difference at constant temperature
- State Ohm's Law: *Current through a conductor is directly proportional to the potential difference across the conductor at constant temperature*

- Distinguish between Ohmic and non-Ohmic conductors
- Define resistance as *a material's opposition to the flow of electric current*
- State that the unit of resistance is the ohm
- Calculate the effective resistance of resistors in series using $R_T = R_1 + R_2$
- Calculate the effective resistance of resistors in parallel using $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
- Interpret circuit diagrams containing a source, switches, resistors, ammeters and voltmeters
- Solve problems using the mathematical expression of Ohm's Law $R = \frac{V}{I}$ for series and parallel circuits, limited to a maximum of three external resistors

2. Power and Energy

- Solve problems using electrical energy $W = Pt$
- State that electrical energy is measured in joules (J)
- Know that electrical power dissipated in a device is equal to the product of the potential difference across the device and current flowing through it
- Solve problems using $P = VI$ or $P = I^2R$ or $P = \frac{V^2}{R}$
- Solve problems using $W = VIt \quad or \quad W = I^2Rt \quad or \quad W = \frac{V^2}{R}t$
- Know that the kilowatt hour (kWh) is a unit of energy and that 1 kWh is the amount of energy used when 1 kilowatt of electricity is used for 1 hour
- Calculate the cost of electricity usage given the power specifications of the appliances used as well as the duration if the cost of 1 kWh is given

3. Internal Resistance and Series and Parallel Networks

- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel for a maximum of three external resistors
- State that a real battery has internal resistance
- Define *emf* as *the total energy supplied per coulomb of charge by the cell*
- The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf: $emf = V_{load} + V_{internal\ resistance}$ or $emf = IR_{ext} + Ir$
- Solve circuit problems in which the internal resistance of the battery must be considered
- Solve circuit problems, with internal resistance, involving series-parallel networks of resistors to a maximum of three external resistors

F. Electrodynamics

1. Electromagnetism

- State that a magnetic field exists around a permanent magnet or a current carrying conductor
- Draw the magnetic field lines and determine the direction of the magnetic field associated with:
  - A straight current carrying conductor
  - A current carrying loop (single) coil of wire
  - A solenoid
- State that a force might act on a current carrying conductor placed in a magnetic field
- Determine the direction of the force acting on a current carrying conductor when the current carrying conductor is perpendicular to the magnetic field

2. Direct Current Motors

- State that motors convert electrical energy to mechanical energy
- Explain why a current carrying coil placed in a magnetic field will turn by referring to the forces exerted on the sides of the coil perpendicular to the field
- Given a diagram of a direct current (d.c.) motor, explain the basic principles of operation including why a d.c. motor has a split ring commutator

3. Electromagnetic Induction

- State that magnetic flux density (B) is a representation of the magnitude and direction of the magnetic field
- Describe that for a loop of area (A) in the presence of a uniform magnetic flux density (B), the magnetic flux (Φ) passing through the loop is defined as $\Phi = BA\cos\theta$ where θ is the angle between the magnetic flux density (B) and the normal to the loop of the area (A). No calculations required
- Define magnetic flux linkage *as the product of the number of turns on the coil and the flux through the coil* ($N\Phi$)
- Infer from appropriate experiments on electromagnetic induction:
  - That changing magnetic flux can induce an emf in a circuit
  - That the direction of the induced emf opposes the change producing it
  - The factors affecting the magnitude of the induced emf
- State Faraday's law of electromagnetic induction: *the emf induced is directly proportional to the rate of change of magnetic flux (flux linkage)*
- State Lenz's law: *the induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic flux*
- Apply Lenz's law qualitatively (e.g. For relative motion of magnets and coils, generators and transformers)
- Explain simple applications of electromagnetic induction (e.g. The induced current and its direction when a magnet is passed through a coil)

4. Alternating Current Generators and Transformers

- State that generators convert mechanical energy to electrical energy
- Use the equation $emf = -\frac{N\Delta\Phi}{\Delta t}$ for Faraday's law to explain qualitatively the operation of generators and transformers. (No calculations required)
- State with reasons which factors affect the emf induced
- Given a diagram, explain the basic principle of an a.c. generator (alternator) in which a coil is mechanically rotated in a magnetic field
- State that a a.c. generator has a slip ring
- Show an understanding of the principle of operation of a simple iron-cored transformer
- State that for an ideal transformer, input power is equal to output power
- Solve problems using $V_p I_p = V_s I_s$ and $\frac{N_S}{N_p} = \frac{V_S}{v_p}$

5. Alternating Current

- Discuss the scientific and economic advantages of high voltages and low currents for the transmission of electrical energy through the national grid
- Draw a graph of potential difference vs time and current vs time for an alternating current (a.c.) circuit and Recognise that these graphs are sinusoidal
- Relate the potential difference vs time graph to the emf produced by an a.c. generator (e.g. indicate how the position of the coil relative to the magnetic field relates to the magnitude of the emf)
- Define a diode as *a component that only allows current to flow in one direction*
- Distinguish graphically between half-wave and full-wave rectification
- Explain how a single diode is used for the half-wave rectification of an alternating current
- Given a circuit diagram of a bridge rectifier, explain how four diodes are used for the full-wave rectification of an alternating current

G. Photons and Electrons

1. Photoelectric Effect

- State that the speed of light in a vacuum is constant $\left(c = 3 \times 10^8 m.s\right)^{-1}$
- Solve problems using the equation $c = f\lambda$
- State that the energy of a photon is directly proportional to the frequency of the light
- Solve problems using the equation $E = hf$
- Describe the photoelectric effect as the process that occurs when light shines on a metal and electrons are ejected

- State the significance of the photoelectric effect: it establishes the quantum theory and it illustrates the particle nature of light
- Define threshold (cut-off) frequency (f_o) as *the minimum frequency of incident radiation at which electrons will be emitted from a particular metal*
- Define work function (W_o) as *the minimum amount of energy needed to emit an electron from the surface of a metal* and know that the work function is material specific
- Know that the threshold frequency corresponds to a maximum wavelength
- Apply the photo-electric equation:

  $E = W_0 + E_{K(max)}$ where $E = hf$ *and* $W_0 = hf_0$

  $E_{K(max)} = \frac{1}{2} m v_{max}^2$
- Explain why the number of electrons ejected per second increases with the intensity of the incident radiation provided the frequency is above the threshold frequency
- Explain why if the frequency of the incident radiation is above the threshold frequency, then increasing the frequency of the radiation will increase the maximum kinetic energy of the ejected electrons

2. Emission spectra

- Explain the source of atomic emission spectra (of discharge tubes) and their unique relationship to each element
- Relate the lines on the atomic spectrum to electron transitions between energy levels
- Calculate the energy associated with a transition and the corresponding wavelength or frequency using $E = hf$

II. CHEMISTRY

A. Quantitative Chemistry

1. Balanced Chemical Equations

- Know the name and formula of the following polyatomic ions: ammonium, chlorate, ethanoate, hydroxide, nitrate, nitrite, permanganate, hydrogen carbonate, hydrogen sulphate, carbonate, dichromate, sulphate, sulphite, phosphate
- Write chemical formulae using the periodic table and knowledge of polyatomic ions
- Represent chemical changes using balanced reaction equations i.e. translate word equations into chemical equations with formulae, using subscripts to represent phases (s), (ℓ), (g) and (aq)
- Balance reaction equations by inspection
- Interpret balanced reaction equations in terms of
  - conservation of atoms
  - conservation of mass (use relative atomic masses)

2. The Mole Concept

The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants

- Describe the mole as the SI unit for amount of substance
- Relate amount of substance to relative atomic mass
- State that one mole contains Avogadro's number of particles $\left(N_A = 6,02 \times 10^{23} mol^{-1}\right)$)
- Define molar mass *as the mass in grams of one mole of that substance*
- Calculate the molar mass of a substance given its formula
- Solve problems using the equation $n = \frac{m}{M}$
  Where *n* = number of moles, *m* = mass of substance and *M* = molar mass

3. Molar Volume of Gases

- Know and use the fact that 1 mole of gas occupies 22,4 dm^3 at 0^{o}C (273 K) and at 1 atmosphere (101,3 kPa)
- Solve problems using $V = nV_m$ where $V_m = 22,4dm^3$ is the molar volume

4. Concentration of Solutions

- Define solute as *the substance that is dissolved in the solution*
- Define solvent as *the substance in which another substance is dissolved, forming a solution*
- Identify the solute and/or solvent for a particular solution
- Define concentration *as the number of moles of solute per unit volume of solution*
- Calculate molar concentration of a solution using the equation $c = \frac{n}{V}$
- Define a standard solution *as a solution of known concentration*
- Describe quantitatively and qualitatively how to make up a standard solution

5. Stoichiometric Calculations

- Perform stoichiometric calculations using balanced equations (may include limiting reagents)
- Perform stoichiometric calculations to determine the percentage yield of a chemical reaction

B. Chemical Bonding

1. Intramolecular Bonds

- Define an intramolecular bond as occurring between atoms within molecules
- Define electronegativity as *a measure of the tendency of an atom to attract a bonding pair of electrons*
- Define a covalent bond as *a sharing of at least one pair of electrons by two atoms*
    - Non - polar covalent (pure covalent) is *an equal sharing of electrons*
    - Polar covalent is *unequal sharing of electrons leading to a dipole forming* (as a result of electronegativity difference)
- Define an ionic bond as *a transfer of electrons and subsequent electrostatic attraction*
- Define metallic bonding as *being between a positive kernel and a sea of delocalised electrons*
- In giant structures such as diamond, graphite and silicon dioxide melting and boiling points are high due to strong covalent bonds being broken
- Identify that in giant ionic solids (e.g. sodium chloride), the melting points and boiling points are determined by electrostatic forces of attraction (ionic bonds) between the cations and the anions in the lattice structure

2. Intermolecular Forces

- Identify that in a liquid or a solid there must be forces between the molecules causing them to be attracted to one another, otherwise the molecules would move apart and become a gas.
- Define intermolecular force as *a weak force of attraction between molecules or between atoms of noble gases*
- Distinguish between intermolecular forces and intramolecular bonds
- Name and explain the origin of the different intermolecular forces:
  - Van der Waals forces
    - i. dipole-dipole
    - ii. ion-dipole
    - iii. induced dipole (London forces)
  - Hydrogen bonding as a special case of dipole-dipole forces
- Identify that within simple molecular substances the melting point and boiling point are affected by the strength (influenced by number of electrons and polarity of molecule) and the relative number of the intermolecular forces

C. Energy Change & Rates of Reactions

1. Energy Changes in Reactions (Exothermic and Endothermic Reactions)

- Define *heat of reaction (ΔH) as the net change of chemical potential energy of the system*
- Define *exothermic reactions as reactions which transfer potential energy into thermal energy*
- Define *endothermic reactions as reactions which transfer thermal energy into potential energy*
- Identify that bond breaking is endothermic and that bond formation is exothermic. No calculations will be required
- Identify that a stronger bond requires more energy to break and releases more energy when formed
- State that $\Delta H > 0$ for endothermic reactions
- State that $\Delta H < 0$ for exothermic reactions

2. Activation Energy

- Define activation energy as *the minimum energy required to start a chemical reaction*. Colliding molecules must have, apart from the correct orientation, a kinetic energy equal to or bigger than the activation energy of a reaction before the reaction can take place
- Define the activated complex *as a temporary transition state between the reactants and the products*
- Draw free hand potential energy profile graphs of endothermic reactions and exothermic reactions (with reactants, products, activation energy, activated complex and ΔH labelled)

3. Rates of Reaction

(a) Rates of Reaction and Factors Affecting Rate

- Define reaction rate *as the change in concentration per unit time of either a reactant or product*
- List the factors which affect the rate of chemical reactions. (Nature of reacting substances, surface area (solid), concentration (solution), pressure (gas), temperature and catalyst)
- Explain in terms of collision theory how the various factors affect the rate of chemical reactions
- Use a Maxwell Boltzmann distribution curve showing the distribution of molecular energies (number of particles against their kinetic energy) to explain why only some molecules have enough energy to react and hence how heating the reactants affects the rate

(b) Measuring Rates of Reaction

- Suggest suitable experimental techniques for measuring the rate of a given reaction including the measuring of gas volumes, turbidity (e.g. precipitate formation), change of colour and the change of the mass of the reaction vessel

(c) Effect of a Catalyst

- Define a catalyst as *a substance that increases the rate of the reaction but remains unchanged at the end of the reaction*
- Explain (in simple terms) how some catalysts function by interacting with the reactants in such a way that the reaction follows an alternative path of lower activation energy
- Use any suitable graph (including e.g. Energy profile graph, Maxwell Boltzmann distribution curve, rate vs time or quantity vs time) to show how adding a catalyst affects the rate of reaction

D. Chemical Equilibrium

1. Chemical Equilibrium and Factors Affecting Equilibrium

- Explain what is meant by:
  - Open and closed systems
  - A reversible reaction
  - Dynamic equilibrium
- List the external factors which shift the position of a particular reaction viz: temperature, pressure and concentration

2. Application of Equilibrium Principles

- State Le Chatelier's principle: '*When an external stress (change in pressure, temperature or concentration) is applied to a system in chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress*'
- Use Le Chatelier's principle to predict the effects of changes of pressure, temperature, and concentration (common ion effect) on the concentrations and amounts of each substance in an equilibrium mixture
- Use collision theory to explain the changes predicted by Le Chatelier's principle
- State that the addition of a catalyst to a system in equilibrium will speed up both the forward and reverse reactions equally and hence have no effect on the position of equilibrium
- Interpret rate graphs
- Interpret amount vs time graphs for chemical reactions in a closed system
- Define yield as *a measure of the extent of a reaction, generally measured by comparing the amount of product against the amount of product that is possible*
- When given chemical equations, diagrams or flow charts, apply rate and equilibrium principles to describe how yields are affected in the following industrial processes:
  - NH_3 – Haber process
  - HNO_3 – Ostwald process
  - H_2SO_4 – including the Contact process

3. Equilibrium Constant

- Write down an expression for the equilibrium constant having been given the equation for the reaction
- State that temperature is the only factor which influences the **value** of the equilibrium constant K_C
- Predict and explain how temperature influences the K_C value for a particular equilibrium reaction
- Calculate K_C given
  - Equilibrium concentrations or moles and volumes of all relevant species
  - Initial concentrations (or moles) of all species and the equilibrium concentration (or moles) of one species
- Calculate the equilibrium concentration of one of the reactants or one of the products given the value of K_C and other relevant information
- Explain the significance of high and low values of the equilibrium constant

E. Acids & Bases

1. Acid – Base Reactions

- Define acid and bases in terms of the Lowry-Brønsted model. (*An acid is defined as a proton donor. A base is defined as a proton acceptor*)
- Name and write the formula of the following common strong acids (e.g. HCl – hydrochloric acid, H_2SO_4 – sulphuric acid and HNO_3 – nitric acid) and the following weak acids (e.g. HF – hydrofluoric acid, H_3PO_4 – phosphoric acid, H_2SO_3 – sulphurous acid and CH_3COOH – ethanoic acid)
- Name and write the formula of some common strong bases (group 1 hydroxides) and weak bases (ammonia solution and carbonates)
- Write the reaction equations, with double arrows to show reversibility, for ionisation of any known or given acids dissolving in water
- Write the reaction equations, with double arrows to show reversibility, for dissociation of any known or given bases dissolving in water
- Define a strong acid as *an acid that ionises almost completely in an aqueous solution*
- Define a strong base as *a base that dissociates almost completely in an aqueous solution*
- Define a weak acid as *an acid that only ionises partially in an aqueous solution*
- Define a weak base as *a base that only dissociates partially in an aqueous solution*
- State what is meant by a concentrated acid and a concentrated base
- State what is meant by a dilute acid and a dilute base
- Interpret the strength of an acid from a given K_a value
- Interpret the strength of a base from a given K_b value
- Explain how conductivity can be used as a measure of acid strength
- Identify polyprotic acids on the basis of being able to donate more than one proton
- Explain the auto-ionisation (autoprotolysis) of water
- Define K_w for water at 25°C as $K_w=[H_3O^+][OH^-]$
- Explain the pH scale as the measure of hydronium ion (H_3O^+) concentration in water at 25°C
- Explain qualitatively the pH range of 0 to 14
- Define a *salt as a substance in which the hydrogen of an acid has been replaced by a cation*
- Write balanced chemical equations representing acid reactions:
  - acid + active metal → salt + hydrogen (NB: A redox reaction)
  - acid + metal oxide → salt + water
  - acid + metal hydroxide → salt + water
  - acid + metal carbonate → salt + carbon dioxide + water
- Define *neutralisation as the point where an acid and base have reacted so neither is in excess. Also defined as the equivalence point*
- Identify indicators as weak acids and use Le Chatelier's principle to predict the colour of the indicator in different acidic and basic media
- Define hydrolysis of a salt as *a reaction with water where water itself is decomposed*

- Given a particular salt, identify the acid and base that could react to produce that salt and hence
- When given the equation to represent the hydrolysis of a salt predict the pH of this salt in solution
- Describe and explain the physical process of performing a titration to ensure the appropriate precision
- Select suitable indicators for the relevant titrations from a table of given indicators and their pH ranges. Titrations between strong acid/strong base; strong acid/weak base; weak acid/strong base are considered to be relevant
- Perform calculations based on titration reactions

F. Electrochemistry

1. Redox Reactions

- Define *oxidation as the loss of electrons*
- Define *reduction as the gain of electrons*
- Define an oxidising agent as *a substance that accepts electrons*
- Define a reducing agent as *a substance that donates electrons*
- Define anode as *the electrode where oxidation takes place*
- Define cathode as *the electrode where reduction takes place*

2. Standard Electrode Potentials

- State 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
- Use the Table of Standard Electrode Potentials to calculate the emf of a standard galvanic cell using $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$
- Use a positive value of the standard emf (E^{θ}) as an indication that the reaction is spontaneous under standard conditions

3. Writing of Equations Representing Oxidation and Reduction Half Reactions and Redox Reactions

- Predict the half-cell in which oxidation will take place
- Predict the half-cell in which reduction will take place
- Write equations for half-reactions taking place at the anode and cathode
- Deduce the overall ionic cell reaction by combining two half-reactions
- Predict the half reaction and identify the electrode at which oxidation takes place (anode)
- Predict the half reaction and identify the electrode at which reduction takes place (cathode)
- Identify the oxidising agent and the reducing agent for a redox reaction

4. Galvanic Cells

- Describe the galvanic cell in terms of:
  - self-sustaining electrode reactions
  - conversion of chemical energy to electrical energy

5. Relation of Current and Potential to Rate and Equilibrium

- State that the galvanic cell has the capacity to deliver current until the reaction reaches chemical equilibrium or has run to completion
- State that once a galvanic cell reaches chemical equilibrium or has run to completion the voltage of the cell equals zero
- Qualitatively, using Le Chatelier's principle, predict the effect of changing concentration on the voltage of a galvanic cell. (I.e. all the factors that favour the forward reaction increase the voltage of the galvanic cell and factors that favour the reverse reaction decrease the voltage. E.g. Increasing the concentration of the reactants or decreasing the concentration of the products increases voltage)
- State that increased surface area of the terminals increases the rate of the reaction which therefore increases the cells capacity to deliver current but does not affect the emf of the cell
- State that the wider, shorter and more conductive salt bridge lowers internal resistance thereby increasing the capacity of the cell to deliver current but does not affect the emf of the cell

6. Understanding of the Processes and Redox Reactions taking place in Cells

- Describe
  - the movement of ions through the solutions,
  - the electron flow in the external circuit of the cell,
  - the half reactions at the electrodes and
  - the function of the salt bridge in galvanic cells
- Use cell notation to represent a galvanic cell
- Draw an annotated diagram of a galvanic cell

7. Applications of Galvanic Cells

- Given suitable information and half-reactions where appropriate, predict
  - Direction of the reaction
  - Reactants used and products formed
  - The E^{θ} value of the cell

8. Electrolytic Cells

- Describe the electrolytic cell in terms of:
  - electrode reactions that are sustained by a supply of electrical energy
  - conversion of electrical energy into chemical energy
- Draw an annotated diagram of an electrolytic cell

- Write equations for half-reactions taking place at the anode and cathode
- Deduce the overall ionic cell reaction by combining two half-reactions
- Predict the half reaction and identify the electrode at which oxidation takes place (anode)
- Predict the half reaction and identify the electrode at which reduction takes place (cathode)
- Identify the oxidising agent and the reducing agent for an electrolytic reaction

9. Applications of Electrolytic Cells

- Describe, using equations for half-reactions and the equation for the overall cell reaction, the following electrolytic processes:
  - The electrolysis of copper chloride solution
  - An example of simple electroplating with silver or copper
  - The refining of copper
- Given a schematic diagram of any cell used in industrial processes for the production of chlorine (ie. mercury cell, diaphragm cell, membrane cell):
  - Write the electrochemical reactions taking place at each electrode and the possible competitive reactions that may occur
  - Deduce the overall net cell reaction
  - Identify the potential risks to the environment and the industrial constraints of running each process
- Given a schematic diagram of a cell used in industrial processes for the recovery of aluminium from Bauxite:
  - Write the electrochemical reactions taking place at each electrode
  - Deduce the overall net cell reaction
  - Identify the potential risks to the environment and the industrial constraints of running this process

G. Organic Chemistry

1. Uniqueness of Carbon

- Describe organic molecules as molecules containing carbon atoms with the exception of carbon dioxide, carbon monoxide, diamond, graphite, carbonates, carbides and cyanides
- State that carbon has a valency of four in a tetrahedral arrangement
- Carbon atoms can form single, double or triple bonds
- State that carbon forms strong covalent bonds with itself and many other elements
- Describe carbon as the basic building block of organic compounds that recycles through the earth's air, water, soil, and living organisms

2. Organic Molecular Structures – Functional Groups, Saturated and Unsaturated Structures; Isomers

- Define
  - a functional group *as an atom or a group of atoms that form the centre of chemical activity in the molecule*
  - a hydrocarbon *as a compound containing only carbon and hydrogen atoms*
  - an homologous series *as a series of similar compounds which have the same functional group and have the same general formula, in which each member differs from the previous one by a single* CH_2 *unit*
- Draw structural, condensed structural (semi-structural) and molecular formulae for compounds belonging to the following homologous series: alkanes, alkenes, haloalkanes, alcohols, carboxylic acids and esters (up to 8 carbon atoms).
- Define
  - a saturated compound *as a compound in which all of the bonds between carbon atoms are single bonds*
  - an unsaturated compound *as a compound in which there is at least one double and/or triple bond between carbon atoms*
  - isomers *as compounds having the same molecular formula but different structural formulae*
- Identify compounds that are saturated and unsaturated
- Identify compounds that are isomers (up to 8 carbon atoms). Isomers are restricted to structural isomers: (1) chain isomers (different chain); (2) positional isomers (different position of the same functional group) and (3) functional isomers (different functional group). No cis-, trans- or stereo isomerism will be examined

3. IUPAC Naming and Formulae

- Write the IUPAC name when given the formula of compounds in the homologous series: alkanes, alkenes, haloalkanes, alcohols, carboxylic acids and esters (up to 8 carbon atoms)
- Write the structural formula when given the IUPAC name of compounds in the homologous series: alkanes, alkenes, haloalkanes, alcohols, carboxylic acids and esters (up to 8 carbon atoms)

NOTE:

- Naming and drawing of organic compounds is restricted to one type of functional group per compound and to a maximum of two functional groups of the same type per compound.
- The only substituent chains that are allowed in naming and reactions are: methyl- and ethyl- groups.
- A maximum of THREE substituent chains (alkyl substituents) are allowed on the parent chain

4. Relationship between Physical Properties and Structure

- Recognise the relationship between physical properties (melting point, boiling point, viscosity and solubilities) and intermolecular forces as influenced by
  - Number and type of functional groups
  - Chain length
  - Branched chains

5. Organic Chemical Reactions (ONLY alkanes, alkenes, haloalkanes, alcohols, carboxylic acids and esters)

- Classify and identify a reaction as combustion, substitution, addition or elimination

(a) Combustion Reactions

- Explain the importance of fossil fuels in terms of their ability to transfer chemical potential energy into heat energy (exothermic)
- Write balanced chemical equations to represent the complete combustion of alkanes, alkenes and alcohols with excess oxygen to produce water and carbon dioxide
- State that combustion reactions are exothermic

(b) Substitution Reactions

- When given the appropriate reaction conditions, write balanced equations to show the formation of substitution products in the following types of reactions:
  - Alkanes to haloalkanes
    - e.g. $CH_4 + C\ell_2 \rightarrow CH_3C\ell + HC\ell$ (Reaction condition: in the presence of light or heat)
  - Haloalkanes to alcohols
    - E.g. $CH_3C\ell + NaOH_{(aq)} \rightarrow CH_3OH + NaC\ell$ (Reaction conditions: heat in an alkali solution)

(c) Addition Reactions

- When given the appropriate reaction conditions write balanced equations to show the formation of addition products in the following types of reactions:
  - Hydrogenation: Addition of H_2 to any alkene
  - e.g. $CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$ (Reaction condition: alkane dissolved in a non polar solvent with the catalyst (Pt, Pd, Ni) in a H_2 atmosphere)
  - Halogenation: Addition of X_2 ($X = C\ell$, Br)
    e.g. $CH_2 = CH_2 + C\ell_2 \rightarrow CH_2C\ell - CH_2C\ell$
  - Hydrohalogenation: Addition of HX to any alkene
    e.g. $CH_2 = CH_2 + HC\ell \rightarrow CH_3 - CH_2C\ell$ (Reaction condition: no water may be present)
  - Hydration: Addition of H_2O to any alkene
    e.g. $CH_2 = CH_2 + H_2O \rightarrow CH_3 - CH_2OH$ (Reaction condition: steam and a suitable catalyst e.g. H_3PO_4)
- When two addition products are possible, either will be accepted

(d) Elimination Reactions

- When given the appropriate reaction conditions write balanced equations to show the formation of elimination products in the following types of reactions:
  - Dehydrohalogenation: Elimination of HX from any haloalkane
    e.g. $CH_2C\ell - CH_2C\ell \rightarrow CH_2 = CHC\ell + HC\ell$ (Reaction condition: hot concentrated solution of NaOH or KOH in an ethanol solvent ie, absence of water)
  - Dehydration of alcohols: Elimination of H_2O from any alcohol
    e.g. $CH_3 - CH_2OH \rightarrow CH_2 = CH_2 + H_2O$ (Reaction condition: acid catalysed dehydration – heating of alcohol with an excess of H_2SO_4 or H_3PO_4)
  - Cracking of hydrocarbons: Breaking up of large hydrocarbon molecules into smaller and more useful molecules (Reaction conditions: thermal cracking – high pressures and temperatures without a catalyst; catalytic cracking – lower temperatures and pressures in the presence of a catalyst)

(e) Esterification Reactions

- State that an acid catalysed condensation reaction between an alcohol and a carboxylic acid produces an ester and water
- Identify the alcohol and carboxylic acid used to prepare any given ester
- Given any alcohol and carboxylic acid, identify the ester produced
- Write an equation to represent the preparation of an ester

III. SCIENTIFIC SKILLS

These skills may be examined under any Physics and/or Chemistry content

1. Conversion of Units

- Identify common conversion factors in mass, length, volume, temperature and pressure
- Recognise and convert various metric scales of measurement
- Translate data into the correct units and dimensions using conversion factors and scientific notation
- Recall orders of magnitude

2. Mathematical Relationships (Direct and Inverse Proportion)

- Describe and recognise certain relationships between two variables:
  - y is directly proportional to x
  - y is inversely proportional to x
  - y is directly proportional to x^2
  - y is inversely proportional to x^2
- Organise observations in a data table, analyse the data for trends or patterns, and interpret the trends or patterns, using scientific concepts
- Interpret a graph constructed from experimentally obtained data to identify relationships:
  - y is directly proportional to x
  - y is inversely proportional to x
  - y is directly proportional to x^2
  - y is inversely proportional to x^2
- Select appropriate units and scales for situations involving proportional reasoning

3. Skills needed to analyse Practical Investigations

- Identify an answerable question and formulate a hypothesis to guide a scientific investigation
- Design a simple experiment including appropriate controls
- Identify independent, dependent and fixed variables in an investigation
- Perform and understand laboratory procedures directed at testing a hypothesis
- Select appropriate tools and technology to collect precise and accurate quantitative data
- Correctly read a thermometer, a balance, metric ruler, voltmeter, ammeter, graduated cylinder, pipette, and burette
- Record observations and data using the correct scientific units
- Export data into the appropriate form of data presentation (e.g. equation, table, graph, or diagram)
- Analyse information in a table, graph or diagram (e.g. compute the mean of a series of values or determine the slope of a line, manipulate data to draw a straight line graph e.g. plot F vs $1/r^2$ to establish mathematical relationships)
- Show an understanding of the distinction between precision and accuracy
- Comment on the accuracy and the precision of experimental results
- Analyse experimental results and identify possible sources of bias or experimental error
- Recognise, analyse and evaluate alternative explanations for the same set of observations.
- Formulate a mathematical model that can be used for further investigation based on the relationship between variables (which has been established experimentally)
- Distinguish between qualitative and quantitative analysis of data