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INTRODUCTION

Have you heard about Mindset? Mindset Network, a South African non-profit organisation, was founded in 2002. We develop and distribute quality and contextually relevant educational resources for use in the schooling, health and vocational sectors. We distribute our materials through various technology platforms like TV broadcasts, the Internet (www.mindset.co.za/learn) and on DVDs. The materials are made available in video, print and in computer-based multimedia formats.

At Mindset we are committed to innovation. In the last three years, we have successfully run a series of broadcast events leading up to and in support of the Grade 12 NSC examinations.

Now we are proud to announce our 2012 edition of Exam School. From 15th October till 20th November will bring you revision lessons in nine subjects - Mathematics, Physical Sciences, Life Sciences, Mathematical Literacy, English 1st Additional Language, Accounting, Geography, Economics and Business Studies.

In this exam revision programme we have selected Questions mainly from the Nov 2011 Papers and have tried to cover as many topics as we can. Each topic is about an hour long and if you work through the selected questions you will certainly have increased confidence to face your exams. In addition to the topics and questions in this booklet, we have scheduled 1½ hour live shows a day or two before you write your exams. To get the most out of these shows, we need you to participate by emailing us questions, calling in or posting on twitter, peptxt or facebook.

Since you asked us for late night study sessions and that’s what we’ve planned! You’ll find repeats of our Live shows at 10:30pm every evening. Then from midnight to 6:00 am there are revision lessons too. So if you can’t watch during the day, you can record or watch early in the morning!

GETTING THE MOST FROM EXAM SCHOOL

You must read this booklet! You’ll find the exam overviews and lots of study tips and hints here. Start your final revision by working through the questions for a topic fully without looking up the solutions. If you get stuck and can’t complete the answer don’t panic. Make a note of any questions you have. Now you are ready to watch a Learn Xtra session. When watching the session, compare the approach you took to what the teacher does. Don’t just copy the answers down but take note of the method used. Also make a habit of marking your work by checking the memo. Remember, there are usually more than one way to answer a question. If you still don’t understand post your question on Facebook – you’ll get help from all the other Mindsetters on the page. You can also send an email to helpdesk@learnxtra.co.za and we’ll get back to you within 48 hours.

Make sure you keep this booklet. You can re-do the questions you did not get totally correct and mark your own work. Exam preparation requires motivation and discipline, so try to stay positive, even when the work appears to be difficult. Every little bit of studying, revision and exam practice will pay off. You may benefit from working with a friend or a small study group, as long as everyone is as committed as you are.
We are pleased to announce that we’ll continue to run our special radio broadcasts on community radio stations in Limpopo, Eastern Cape and KZN. This programme is called MTN Learn. Find out more details at www.mtnlearning.co.za. You can also listen online or download radio broadcasts of previous shows. Tuning into radio will give you the chance to learn extra! Look out for additional notes in Newspaper supplements too.

Mindset believes that the 2012 Learn Xtra Spring School will help you achieve the results you want. All the best to the Class of 2012!

CONTACT US
We want to hear from you. So let us have your specific questions or just tell us what you think through any of the following:

LearnXtra helpdesk@learnxtra.co.za
@learnxtra 086 105 8262
www.learnxtra.co.za

BROADCAST SCHEDULES
Exam School (Dstv and Topty 319)
Physical Sciences Paper 2

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIMES</th>
<th>TOPICS</th>
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<tbody>
<tr>
<td>26 October</td>
<td>09:00 – 10:00</td>
<td>Organic Molecules &amp; Properties</td>
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<tr>
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<td>10:00 – 11:00</td>
<td>Organic Reactions</td>
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<td>11:00 – 12:00</td>
<td>Rates of Reaction</td>
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<td>12:00 – 13:00</td>
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<td>14:30 – 15:30</td>
<td>Chemical Industries</td>
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<td>15:30 – 17:00</td>
<td>LIVE: Paper 2</td>
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<td>17:00 – 18:00</td>
<td>Organic Molecules &amp; Properties</td>
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<td>22:30 – 00:00</td>
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<td>04:00 – 05:00</td>
<td>Organic Molecules &amp; Properties</td>
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- Get the free app at pepclub.mobi
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MTN LEARN RADIO BROADCASTS

EXAM SCHOOL: PHYSICAL SCIENCES P2

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<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Topic</th>
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<td>17:00 -18:00</td>
<td>Organic Molecules &amp; Properties</td>
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<td>26-Oct</td>
<td>18:00 -19:00</td>
<td>Organic Reactions</td>
</tr>
<tr>
<td>28-Oct</td>
<td>17:00 -18:00</td>
<td>Rates &amp; Chemical Equilibrium</td>
</tr>
<tr>
<td>28-Oct</td>
<td>18:00 -19:00</td>
<td>Electrochemistry &amp; Chemical Industries</td>
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Visit www.mtnlearning.co.za for the complete schedule, and free downloads of booklets and past shows.

MTN LEARN: PARTICIPATING COMMUNITY RADIO STATIONS

KwaZulu Natal:
Hindvani Radio 91.5 fm – Durban
Maputaland Radio 102.3 fm – Rest or KZN

Limpopo Province:
Sekgosese Radio 100.3 fm
Greater Tzaneen Radio 104.8 fm
Mohodi FM 98.8 fm
Moletsi 98.6 fm
Univen 99.8 fm

Eastern Cape:
Vukani fm 90.6 – 99.9 fm
Fort Hare Community Radio 88.2 fm
Mdantsane fm 89.5 fm
Nkqubela fm 97.0 fm
Graaff Reinet 90.2 fm
PREPARING FOR EXAMINATIONS

1. Prepare well in advance for all your papers and subjects. You need to start your planning for success in the final examination now. You cannot guarantee success if you only study the night before an exam.

2. Write down the date of your prelim and final exam so that you can plan and structure a study time table for all your subjects.

3. Set up a study time-table according to your prelim and final Grade 12 exam time-table and stick to your study schedule. If you study a small section every day, you will feel you have achieved something and you will not be as nervous by the time you have to go and write your first paper.

4. Your study programme should be realistic. You need to spend no more than 2 hours per day on one topic. Do not try to fit too much into one session. When you cover small sections of work often, you will master them more quickly. The broadcast schedule may help you to make sure you have covered all the topics that are in the exam.

5. When studying don’t just read through your notes or textbook. You need to be active by making summary checklists or mind maps. Highlight the important facts that you need to memorise. You may need to write out definitions and formulae a few times to make sure you can remember these. Check yourself as often as you can. You may find it useful to say the definitions out aloud.

6. Practise questions from previous examination papers. Follow these steps for using previous exam papers effectively:
   - Take careful note of all instructions - these do not usually change.
   - Try to answer the questions without looking at your notes or the solutions.
   - Time yourself. You need to make sure that you complete a question in time. To work out the time you have, multiply the marks for a question by total time and then divide by the total number of marks. In most exams you need to work at a rate of about 1 mark per minute.
   - Check your working against the memo. If you don’t understand the answer given, contact the Learn Xtra Help desk (email: helpdesk@learnxtra.co.za).
   - If you did not get the question right, try it again after a few days.

7. Preparing for, and writing examinations is stressful. You need to try and stay healthy by making sure you maintain a healthy lifestyle. Here are some guidelines to follow:
   - Eat regular small meals including breakfast. Include fruit, fresh vegetables, salad and protein in your diet.
   - Drink lots of water while studying to prevent dehydration.
   - Plan to exercise regularly. Do not sit for more than two hours without stretching or talking a short walk.
   - Make sure you develop good sleeping habits. Do not try to work through the night before an exam. Plan to get at least 6 hours sleep every night.
EXAM TECHNIQUES

1. Make sure you have the correct equipment required for each subject. You need to have at least one spare pen and pencil. It is also a good idea to put new batteries in your calculator before you start your prelims or have a spare battery in your stationery bag.

2. Make sure you get to the exam venue early - don’t be late.

3. While waiting to go into the exam venue, don’t try to cram or do last minute revision. Try not to discuss the exam with your friends. This may just make you more nervous or confused.

4. Here are some tips as to what to do when you receive your question papers:
   Don’t panic, because you have prepared well.
   - You are always given reading time before you start writing. Use this time to take note of the instructions and to plan how you will answer the questions. You can answer questions in any order.
   - Time management is crucial. You have to make sure that you answer all questions. Make notes on your question paper to plan the order for answering questions and the time you have allocated to each one.
   - It is a good idea always to underline the key words of a question to make sure you answer it correctly.
   - Make sure you look any diagrams and graph carefully when reading the question. Make sure you check the special answer sheet too.
   - When you start answering your paper, it is important to read every question twice to make sure you understand what to do. Many marks are lost because learners misunderstand questions and then answer incorrectly.
   - Look at the mark allocation to guide you in answering the question.
   - When you start writing make sure you number your answers exactly as they are in the questions.
   - Make sure you use the special answer sheet to answer selected questions.
   - Think carefully before you start writing. It is better to write an answer once and do it correctly than to waste time rewriting answers.
   - DO NOT use correction fluid (Tippex) because you may forget to write in the correct answer while you are waiting for the fluid to dry. Rather scratch out a wrong answer lightly with pencil or pen and rewrite the correct answer.
   - Check your work. There is usually enough time to finish exam papers and it helps to look over your answers. You might just pick up a calculation, language or a spelling error. In Physical Sciences P2 make sure that every answer has the correct units.
EXAM OVERVIEW

STRUCTURE OF PHYSICAL SCIENCES EXAM PAPERS

Section A (All topics)
One word answers 5 marks
Multiple choice questions 20 marks
Section B (Long questions) 125 marks

PHYSICAL SCIENCE PAPER 2: CHEMISTRY

Matter and Materials ±50 marks
  ● Organic molecules

Chemical Change ±75 marks
  ● Energy and chemical change Grade 11
  ● Rate and extent of reactions
  ● Electrochemical reactions

Chemical Systems ±25 marks
  ● Chlor-alkali industry
  ● Fertiliser industry
  ● Batteries
### ORGANIC MOLECULES

- Give condensed structural, structural and molecular formulae given the IUPAC name, or give the IUPAC name when given the formula for:
  - Alkanes – maximum eight carbon atoms in the longest chain; branched alkanes with maximum three alkyl substituents; maximum two carbon atoms per alkyl substituent; number longest chain beginning at end nearest to first substituent; arrange substituent alphabetically by name; know that alkanes are our most important fuels (fossil fuels); combustion of alkanes (oxidation) is highly exothermic and carbon dioxide and water are produced: \( \text{alkane} + O_2 \rightarrow H_2O + CO_2 \Delta H < 0 \) (revision from Grade 11)

- Cycloalkanes – maximum of six carbons per ring; maximum of three alkyl substituents; maximum two carbon atoms per alkyl substituent.

- Alkenes – maximum of eight carbon atom in the longest chain; branched alkenes with maximum three alkyl substituents; maximum two carbon atoms per alkyl substituent.

- Cycloalkenes - maximum of six carbons per ring; maximum of three alkyl substituents; maximum two carbon atoms per alkyl substituent.

- Dienes – conjugated dienes (two double bonds separated by a single bond), isolated dienes (one or more saturated carbon atoms between two double bond) or cumulated dienes (two double bonds formed to one carbon atom); maximum of eight carbon atoms in the longest chain; branched dienes with maximum of three alkyl substituents; maximum two carbon atoms per alkyl substituent.

- Alkynes - maximum of eight carbon atom in the longest chain; branched alkenes with maximum three alkyl substituents; maximum two carbon atoms per alkyl substituent.

- Haloalkanes – maximum eight carbon atoms in the longest chain; branched haloalkanes – maximum two carbon atoms per alkyl group; haloalkanes can have one or more \( X \)-groups \( (X = F, Cl, Br or I) \) attached; number longest chain beginning at end nearest to first substituent, regardless of whether it is alkyl or halo; give alphabetical preference to substituents when longest chain can be numbered from either side; include cyclic haloalkanes for rings up to six carbon atoms.

- Alcohols – maximum eight carbon atoms in the longest chain; primary, secondary and tertiary alcohols; branched alcohols.
with maximum three alkyl substituents; maximum two carbon atoms per alkyl substituent; number longest chain beginning at end nearest to hydroxyl group

- Carboxylic acids – maximum eight carbon atoms in the longest chain; branched carboxylic acids with maximum three alkyl substituents; maximum two carbon atoms per alkyl substituent; number longest chain beginning at end nearest to carboxyl group.

- Esters – maximum eight carbon atoms in alkyl group (unbranched) attached to oxygen i.e. alcohol side of ester, and maximum of eight carbon atom in carboxylic acid side (unbranched) of ester; know that an ester is the product of an acid catalysed condensation between an alcohol and a carboxylic acid; identify the alcohol and carboxylic acid used to prepare a give ester and vice versa, and write an equation to represent this preparation.

- Aldehydes – maximum of eight carbon atoms in the longest chain; branched aldehydes with maximum three alkyl substituents; maximum two carbon atoms per alkyl group, number longest chain beginning at end nearest to carbonyl group

- Ketones – maximum of eight carbon atoms in the longest chain; branched ketones with a maximum three alkyl substituents; maximum two carbon atoms per alkyl group; number longest chain beginning at end nearest to carbonyl group.

- Explain the terms saturated, unsaturated, homologous series and isomer (structural isomers only).

- Identify compounds that are saturated, unsaturated and are isomers (up to 8 carbon atoms).

| Structure physical property relationships | Recognise and apply to particular examples (for compounds listed above) the relationship between:
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<tbody>
<tr>
<td></td>
<td>- Physical properties (e.g. melting points, boiling points, vapour pressures, viscosities) and intermolecular forces (hydrogen bonding, Van der Waals)</td>
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<td></td>
<td>- Physical properties and type of functional groups</td>
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<tr>
<td></td>
<td>- Physical properties and chain length</td>
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<td></td>
<td>- Physical properties and branched chains</td>
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| Substitution, addition and elimination reactions | Addition reactions: Unsaturated compounds (alkenes, cyclalkenes,) undergo addition reactions
|--------------------------------------------------|--------------------------------------------------|
|                                                 | - Hydrohalogenation
|                                                 |   - Addition of HX to an alkene e.g. $\text{CH}_2 = \text{CH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{Cl}$
|                                                 |   - Reaction conditions: HX (X = Cl, Br, I) added to alkene; no water must be present.
|                                                 |   - (During addition of HX to unsaturated hydrocarbons, the H atom attached to the C atom already having the
greater number of H atoms. The X atom attaches to the more substituted C atom)

<table>
<thead>
<tr>
<th>Halogenation:</th>
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<tbody>
<tr>
<td>- Addition of $X_2$ ($X = Cl, Br$) to alkenes e.g. $CH_2=CH_2 + Cl_2 \rightarrow CH_2Cl\cdot CH_2Cl$</td>
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<tr>
<td>- Reaction conditions: $X_2$ ($X = Cl, Br$) added to alkene</td>
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<th>Hydration</th>
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<td>- Addition of H$_2$O to alkenes e.g. $CH_2=CH_2 + H_2O \rightarrow CH_3 - CH_2OH$</td>
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<tr>
<td>- Reaction conditions: H$_2$O in excess and a small amount of HX or other strong acid ($H_3PO_4$) as catalyst</td>
<td></td>
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<tr>
<td>- (During addition of H$_2$O to unsaturated hydrocarbons, the H atom attaches to the C atom already having the greater number of H atoms. The OH group attaches to the more substituted C-atom)</td>
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<table>
<thead>
<tr>
<th>Hydrogenation</th>
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<tbody>
<tr>
<td>- Addition of H$_2$ to alkenes e.g. $CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$</td>
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<tr>
<td>- Reaction conditions: alkene dissolved in non-polar solvent with the catalyst (Pt, Pd or Ni) in an H$_2$ atmosphere</td>
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</tr>
<tr>
<td>- Addition of H$_2$ to alkynes e.g. $CH\equiv CH + 2H_2 \rightarrow CH_3 - CH_3$</td>
<td></td>
</tr>
<tr>
<td>- Reaction conditions: alkyne dissolved in non-polar solvent with the Pt, Pd or Ni as catalyst in an H$_2$ atmosphere</td>
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- **Elimination reactions:** Saturated compounds (haloalkanes, alcohols, alkanes) undergo elimination reactions:
  - **Dehydrohalogenation**
    - elimination of HX from a haloalkane e.g. $CH_2Cl\cdot CH_2Cl \rightarrow CH_2=CHCl + HCl$
    - Reaction conditions: heat under reflux (vapours condensate and return to reaction vessel during heating) in a concentrated solution of NaOH of KOH in pure ethanol as the solvent i.e. hot ethanolic NaOH/KOH.
    - If more than one elimination product is possible, the major product is the one where the H atom is removed from the C atom with the least number of H atoms
  - **Dehydration of alcohols**
    - Elimination of H$_2$O from an alcohol e.g. $CH_3 - CH_2OH \rightarrow CH_2 = CH_2 + H_2O$
    - Reaction conditions: Acid catalysed dehydration – heating of alcohol with an excess of concentrated H$_2$SO$_4$ (or H$_3$PO$_4$).
    - Gaseous alkenes e.g. ethene can be produced easier when ethanol vapour is passed over heated Al$_2$O$_3$ powder
- If more than one elimination product is possible, the major product is the one where the H atom is removed from the C atom with the least number of H atoms

<table>
<thead>
<tr>
<th>o Cracking of hydrocarbons</th>
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<tbody>
<tr>
<td>- Breaking up of large hydrocarbon molecules into smaller and more useful bits.</td>
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<tr>
<td>- Reaction conditions: high pressures and temperatures without a catalyst (thermal cracking), or lower temperatures and pressures in the presence of a catalyst (catalytic cracking)</td>
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- Substitution reactions:

<table>
<thead>
<tr>
<th>o Interconversion between alcohols and haloalkanes</th>
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<tbody>
<tr>
<td>- Reactions of HX (X = Cl, Br) with alcohols to produce haloalkanes</td>
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<tr>
<td>~ Tertiary alcohols are converted into haloalkanes using HBr or HCl at room temperature. E.g. C(CH₃)₃OH + HBr → C(CH₃)₃Br + H₂O</td>
</tr>
<tr>
<td>~ Primary and secondary bromoalkanes. Treat primary and secondary alcohols with concentrated H₂SO₄ and solid NaBr (or KBr). The H₂SO₄ and solid NaBr react to form HBr: H₂SO₄ + NaBr → HBr + NaHSO₄ The HBr reacts with the alcohol to form the bromoalkane: e.g. CH₃CH₂OH + HBr → CH₃CH₂Br + H₂O</td>
</tr>
<tr>
<td>- Reactions of bases with haloalkanes (hydrolysis) to produce alcohols e.g. C(CH₃)₃X + KOH → C(CH₃)₃OH + KX</td>
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<td></td>
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<tr>
<td>o Haloalkanes from alkanes (prior knowledge from Grade 11)</td>
</tr>
<tr>
<td>- Reaction conditions: X₂ (X = Cl, Br) added to alkane in the presence of light or heat.</td>
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## CHEMICAL CHANGE

### ENERGY AND CHEMICAL CHANGE (GRADE 11)

<table>
<thead>
<tr>
<th>Energy changes in reactions related to bond energy changes</th>
<th>• Explain the concept enthalpy and its relationship to heat of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Define exothermic and endothermic reactions.</td>
</tr>
<tr>
<td></td>
<td>• Identify that bond breaking requires energy (endothermic) and that bond formation releases energy (exothermic).</td>
</tr>
<tr>
<td>Exothermic and endothermic reactions</td>
<td>• State that $\Delta H &gt; 0$ for endothermic reactions, including graph.</td>
</tr>
<tr>
<td></td>
<td>• State that $\Delta H &lt; 0$ for exothermic reactions, including graph.</td>
</tr>
<tr>
<td>Activation energy</td>
<td>• Define activation energy.</td>
</tr>
<tr>
<td></td>
<td>• Explain a reaction process in terms of energy change and relate this change to bond breaking and formation, and to the “activated complex”.</td>
</tr>
</tbody>
</table>

### RATE AND EXTENT OF REACTION

<table>
<thead>
<tr>
<th>Rates of reaction and factors affecting rate (nature of reacting substances, concentration [pressure for gases], temperature and presence of a catalyst)</th>
<th>• Explain what is meant by reaction rate.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• List the factors which affect the rate of chemical reactions. Surface area (solid), concentration (solution), pressure (gas), temperature, and catalyst.</td>
</tr>
<tr>
<td></td>
<td>• Explain in terms of collision theory how the various factors affect the rate of chemical reactions.</td>
</tr>
<tr>
<td>Measuring rates of reaction</td>
<td>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.</td>
</tr>
<tr>
<td>Mechanism of reaction and of catalysis</td>
<td>• Define activation energy. Colliding molecules must have, apart from the correct orientation, sufficient kinetic energy before a reaction can take place.</td>
</tr>
<tr>
<td></td>
<td>• Use a graph 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 adding a catalyst and heating the reactants affects the rate.</td>
</tr>
<tr>
<td></td>
<td>• Explain (in simple terms) how some catalysts function by reacting with the reactants in such a way that the reaction follows an alternative path of lower activation energy.</td>
</tr>
<tr>
<td>Chemical equilibrium and factors affecting equilibrium</td>
<td>• Explain what is meant by:</td>
</tr>
<tr>
<td></td>
<td>o Open and closed systems</td>
</tr>
<tr>
<td></td>
<td>o A reversible reaction</td>
</tr>
<tr>
<td></td>
<td>o Dynamic equilibrium</td>
</tr>
<tr>
<td>Equilibrium constant</td>
<td>• List the factors which influence the value of the equilibrium</td>
</tr>
<tr>
<td>Application of equilibrium principles</td>
<td>ELECTROCHEMICAL REACTIONS</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Write down an expression for the equilibrium constant having been given the equation for the reaction.</td>
<td>Define the galvanic cell in terms of:</td>
</tr>
<tr>
<td>Perform calculations based on $K_c$ values.</td>
<td>o Self sustaining electrode reactions</td>
</tr>
<tr>
<td>Explain the significance of high and low values of the equilibrium constant.</td>
<td>o Conversion of chemical energy to electrical energy</td>
</tr>
<tr>
<td>State Le Chatelier’s principle. Use Le Chatelier’s principle to identify and explain the effects of changes of pressure, temperature and concentration on the concentration and amounts of each substance in an equilibrium mixture. Explain the use of a catalyst and its influence on an equilibrium mixture.</td>
<td>Define the electrolytic cell in terms of:</td>
</tr>
<tr>
<td>Interpret graphs of equilibrium</td>
<td>o Electrode reactions that are sustained by a supply of electrical energy</td>
</tr>
<tr>
<td>Apply the rate and equilibrium principles to important industrial applications.</td>
<td>o Conversion of electrical energy into chemical energy</td>
</tr>
</tbody>
</table>

Electrolytic and galvanic Cells

<table>
<thead>
<tr>
<th>Electrolytic and galvanic Cells</th>
<th>Relation of current and potential to rate and equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the galvanic cell in terms of:</td>
<td>Give and explain the relationship between current in an electrochemical cell and the rate of the reaction.</td>
</tr>
<tr>
<td>o Self sustaining electrode reactions</td>
<td>State that the pd of the cell ($V_{cell}$) is related to the extent to which the spontaneous cell reaction has reached equilibrium.</td>
</tr>
<tr>
<td>o Conversion of chemical energy to electrical energy</td>
<td>State and use the qualitative relationship between $V_{cell}$ and the concentration of product ions and reactant ions for the spontaneous reaction viz. $V_{cell}$ decreases as the concentration of product ions increase and the concentration of reactant ions decrease until equilibrium is reached at which the $V_{cell} = 0$ (the cell is ‘flat’).</td>
</tr>
<tr>
<td>Define the electrolytic cell in terms of:</td>
<td></td>
</tr>
<tr>
<td>o Electrode reactions that are sustained by a supply of electrical energy</td>
<td></td>
</tr>
<tr>
<td>o Conversion of electrical energy into chemical energy</td>
<td></td>
</tr>
<tr>
<td>Define oxidation and reduction in terms of electron (e-) transfer</td>
<td></td>
</tr>
<tr>
<td>Define anode and cathode in terms of oxidation and reduction</td>
<td></td>
</tr>
<tr>
<td>Define oxidising and reducing agents in terms of electron transfer / oxidation numbers</td>
<td></td>
</tr>
</tbody>
</table>

Understanding of the processes and redox reactions taking place in cells

<table>
<thead>
<tr>
<th>Understanding of the processes and redox reactions taking place in cells</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe:</td>
<td></td>
</tr>
<tr>
<td>o The movement of ions through the solutions</td>
<td></td>
</tr>
<tr>
<td>o The electron flow in the external circuit of the cell</td>
<td></td>
</tr>
<tr>
<td>o And their relation to the half reactions at the electrodes</td>
<td></td>
</tr>
<tr>
<td>o The function of the salt bridge</td>
<td></td>
</tr>
<tr>
<td>Use cell notation or diagrams to represent a galvanic cell</td>
<td></td>
</tr>
</tbody>
</table>
### Standard electrode potentials

- Give the standard conditions under which standard electrode potentials are determined.
- Describe:
  - The standard hydrogen electrode
  - 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 Reduction Potentials to deduce 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.

### Writing of equations representing oxidation and reduction half-reactions and redox reactions

- Predict the half-cell in which oxidation will take place when connected to another half-cell.
- Predict the half-cell in which reduction will take place when connected to another half-cell.
- Write equations for reactions taking place at the anode and cathode.
- Deduce the overall cell reaction by combining two half-reactions.
- Describe, using half equations and the equation for the overall cell reaction, the following electrolytic processes:
  - The decomposition of copper chloride
  - A simple example of electroplating (e.g. the refining of copper)
- Describe, using half equations and the equation for the overall cell reaction, the layout of the particular cell using a schematic diagram and potential risks to the environment of the following electrolytic processes used industrially:
  - The production of chlorine (see grade 12 chemical systems: the chloroalkali industry).
  - The recovery of aluminium metal (in South Africa) from bauxite mined in Australia.
### CHEMICAL SYSTEMS

#### CHEMICAL INDUSTRIES

<table>
<thead>
<tr>
<th>Chloroalkali industry (soap, PVC, etc.)</th>
<th>Given diagrams of the membrane cell used industrially to produce chlorine electrolytically:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o Explain the process using half reactions and the overall redox reaction taking place in the cells</td>
</tr>
<tr>
<td></td>
<td>o Identify all the products and give a use of each</td>
</tr>
<tr>
<td></td>
<td>o Make clear the meaning of the term electrolytic cell</td>
</tr>
<tr>
<td></td>
<td>o Identify the cathode (reduction, H₂) and anode (oxidation, Cl₂)</td>
</tr>
<tr>
<td></td>
<td>o Describe the function of the cell membrane where applicable (ion exchange)</td>
</tr>
<tr>
<td></td>
<td>• Identify the benefits to humankind of the products of this process.</td>
</tr>
<tr>
<td></td>
<td>• Identify risks associated with operating each of this cell.</td>
</tr>
<tr>
<td></td>
<td>• Given a flow diagram of, for example, the membrane cell (or even an unknown process pertinent to the manufacture of these products), be able to answer questions on aspects of the process.</td>
</tr>
<tr>
<td></td>
<td>• For example identify the reactants and products of a particular step, or the purpose of a sequence of steps.</td>
</tr>
<tr>
<td>Fertiliser industry (N, P, K)</td>
<td>List, for plants:</td>
</tr>
<tr>
<td></td>
<td>o Three essential nutrients and their source; C, H and O (atmosphere (CO₂) and rain)</td>
</tr>
<tr>
<td></td>
<td>o Three primary nutrients and their source N, P and K (the soil)</td>
</tr>
<tr>
<td></td>
<td>• Explain the function of N, P and K in plants.</td>
</tr>
<tr>
<td></td>
<td>• List for humans the four major elements, and their source, on which the body relies for form and function; C, H, O and N (atmosphere, water and food – animals and plants).</td>
</tr>
<tr>
<td></td>
<td>• Match the parts of the human body that utilise particular chemical elements with those from a list of primary, secondary and micronutrients in plants (e.g. P, K, Fe, Ca, …).</td>
</tr>
<tr>
<td></td>
<td>• Give the form in which plants and animals absorb N, P and K (e.g. nitrates, phosphates, potassium salts, … implies the need to fix nitrification).</td>
</tr>
<tr>
<td></td>
<td>• Give the source of N (guano), P (bone meal) and K (German mines) before and after the First World War.</td>
</tr>
<tr>
<td></td>
<td>• Interpret the N:P:K fertilizer ratio</td>
</tr>
<tr>
<td></td>
<td>• Describe and explain (rates, yields, neutralisation, …), using</td>
</tr>
</tbody>
</table>
### Physical Sciences P2 Learner's Guide

Exam School 2012

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<table>
<thead>
<tr>
<th>chemical equations where ever appropriate, these aspects of the industrial manufacture of fertilizers, given diagrams, flow charts and so on:</th>
</tr>
</thead>
<tbody>
<tr>
<td>o N₂ – fractional distillation of air</td>
</tr>
<tr>
<td>o H₂ – at SASOL from coal and steam</td>
</tr>
<tr>
<td>o NH₃ – Haber process</td>
</tr>
<tr>
<td>o HNO₃ – the Ostwald process</td>
</tr>
<tr>
<td>o H₂SO₄ – including the contact process</td>
</tr>
<tr>
<td>• Give sources of potash (mined imported potassium salts like KNO₃, K₂SO₄, KNO₃,)</td>
</tr>
<tr>
<td>• Describe the term eutrophication and:</td>
</tr>
<tr>
<td>o What causes it</td>
</tr>
<tr>
<td>o Its consequences</td>
</tr>
<tr>
<td>o Be able to identify circumstances that can lead to it from a supplied text</td>
</tr>
<tr>
<td>o Suggest ways to prevent it</td>
</tr>
<tr>
<td>o Suggest ways to solve the problems that arise from it</td>
</tr>
<tr>
<td>• Evaluate the use of inorganic fertilizers on humans and the environment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Batteries, torch, car, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Use the knowledge gained studying galvanic cells to provide, for an unknown cell:</td>
</tr>
<tr>
<td>o The equation for the cell reaction given the half equations</td>
</tr>
<tr>
<td>o The cell voltage if applied with the voltage of the half cells</td>
</tr>
<tr>
<td>• Explain and use the concepts:</td>
</tr>
<tr>
<td>o Energy stored in cells and batteries W = Vq</td>
</tr>
<tr>
<td>o Cell capacity and use the unit Amp-hour (Ah and mAh) and the equation q = It</td>
</tr>
<tr>
<td>o Primary cells and secondary cells.</td>
</tr>
</tbody>
</table>
ORGANIC MOLECULES & PROPERTIES

STUDY NOTES

ORGANIC MOLECULES

Important features of Carbon

• Carbon has a valency of 4 (can form 4 bonds), and has 4 valence electrons (outermost energy level).
• Carbon has the ability to form long chains with other C atoms – called catenation.
• Carbon has the ability to form rings by joining with other C atoms

Representations of Organic Molecules

• Molecular formula: \( \text{C}_6\text{H}_{13}\text{OH} \)
• Condensed formula: \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \)
• Structural formula:

HYDROCARBONS

They are molecules that contain only hydrogen and carbon atoms. There are an infinite number of different hydrocarbon molecules.

Functional group: The special arrangement of atoms in part of a molecule that gives the molecule particular characteristics.

Types of hydrocarbons

• Saturated – single bonds only (functional group)
• Unsaturated – double and triple bonds (functional group)

Homologous Series

Family or group of molecules that have the same functional group and the same general formula.

Alkanes

• Single covalent bonds
• SATURATED molecule.
• General formula: \( \text{C}_n\text{H}_{2n+2} \)

\( \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \) butane

Alkenes

• have one or more C=C double bonds
• The general formula: \( \text{C}_n\text{H}_{2n} \).
• UNSATURATED molecule

\( \text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_3 \) but-1-ene

Alkynes

• One or more triple bonds
• General formula: \( \text{C}_n\text{H}_{2n-2} \)
• UNSATURATED molecule

\( \text{CH}≡\text{C}-\text{CH}_2-\text{CH}_3 \) but-1-yne
Naming alkyl groups (side chains)

<table>
<thead>
<tr>
<th>Alkyl group structure</th>
<th>Alkyl name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃ -</td>
<td>methyl</td>
</tr>
<tr>
<td>CH₃CH₂ -</td>
<td>ethyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₂ -</td>
<td>propyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₂CH₂ -</td>
<td>butyl</td>
</tr>
</tbody>
</table>

RULES FOR NAMING ORGANIC COMPOUNDS (IUPAC RULES)

- Identify the functional group of the molecule – this determines the ending of the name, e.g. all alkanes end in –ane.
- Find the longest continuous carbon chain and allocate its prefix according to the number of carbon atoms in the chain (see table for prefixes).

<table>
<thead>
<tr>
<th>Name prefixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of C atoms</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
</tbody>
</table>

- Number the carbon atoms in the chain. Number them so that the functional group is on the carbon of lowest possible number. Double and triple bonds take preference over side chains.
- Name the branched group according to the number of carbon atoms it has, and give it a number according to the carbon atom to which it is attached.
- If there is more than one branched group of the same kind, use the Greek prefixes di, tri, tetra, penta and so on to indicate this.
- If a halogen atom is attached to the carbon chain, it is treated as an alkyl group and then the prefixes: fluoro-, chloro-, bromo -, and iodo – are used.
Alcohols

- O-H (hydroxyl) is the functional group. (Not called hydroxide OH⁻)
- Named using the ending –ol. –O-H group gets the lowest possible number
- Alcohols are oxidised to carboxylic acids when treated with strong oxidising agents
- Alcohol molecules have a non-polar hydrocarbon end and a polar –O-H section
- Alcohols are solvents for polar and non-polar solutes
- Classification of alcohols depends on the number of carbons attached to the carbon bonded to the hydroxyl: Primary – only 1 carbon, Secondary (2 carbons) and Tertiary (3 carbons)

Carbolic Acids

- Compounds that have the carboxyl, -COOH functional group
- The ending -oic acid denotes that we are dealing with a carboxylic acid.
- Are relatively weak acids.

Esters

- These are compounds that have the C-O- C functional group.
- Esters arise by the reaction between a carboxylic acid and an alcohol:
- All esters consist of two parts in their name:
  - First part: an alkyl derived from the alcohol used,
  - Second part (separate word) ends in -anoate derived from a carboxylic acid (has the double bond O)

Ketones

- Functional group: Carbonyl group (C=O) found in the middle of the molecule
- Suffix: -one (pronounced own)
  - Example: propanone
  - The carbonyl group (C=O) is polar.

Aldehydes

- Functional group: Carbonyl group (C=O) found at the end of the molecule
- Suffix: -al
  - Example: propanal

ISOMERS

Isomers are compounds which have the same molecular formula, but different structural formulae.
PHYSICAL PROPERTIES OF ORGANIC MOLECULES

Molecules are held together by intermolecular forces. In order to separate these molecules from each other requires energy. The stronger the intermolecular forces, the more energy that is required to separate or break these bonds. This will lead to a higher melting point, boiling point, etc.

Boiling and Melting Points
As the strength of the intermolecular forces increase, the boiling point and melting point will increase. Thus molecules where there are hydrogen bonds present will have a higher melting point and boiling point than those molecules where there are weaker London forces or Van der Waals forces present.

Vapour Pressure
Vapour pressure is the amount of pressure that the gaseous molecules exert above the surface of the liquid phase. The vapour pressure will decrease as the size of the molecule increases (chain length). Vapour pressure is an indication that there are weak intermolecular forces present in the liquid phase.

Viscosity
A liquid that has a low viscosity will be able to flow more easily. Thus, where hydrogen bonds are present, there will be a much higher degree of viscosity. The opposite is true for the weak Van der Waals forces. Viscosity will also increase as the length of the carbon chain increases.

Density
The density of organic molecules will increase as the length of the chain increases.

Surface Area
As the surface area of the molecule decreases, there will be lower boiling and melting points as the intermolecular forces will be weaker.

Phases
As the chain length increases, the melting and boiling points will increase. The smaller molecules will then be gases at room temperature and the longer chain lengths will be liquids or solids at room temperature.
Question 1 (Adapted from Nov 2011, NSC, P2)

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

1.1 Which ONE of the following general formulae represents alkynes?
   
   A $C_nH_{2n+2}$  
   B $C_nH_{2n-2}$  
   C $C_nH_{2n}$  
   D $C_nH_{2n-1}$  

1.2 Which ONE of the following pairs of compounds correctly represents the products formed during the COMPLETE combustion of octane?
   
   A CO and H$\text{}_2$O  
   B CO and H$\text{}_2$  
   C CO$\text{}_2$ and H$\text{}_2$  
   D CO$\text{}_2$ and H$\text{}_2$O  

1.3 Which ONE of the following pairs of reactants can be used to prepare the ester ethyl methanoate in the laboratory?
   
   A Ethane and methanoic aid  
   B Methanol and ethanoic acid  
   C Ethanol and methanoic acid  
   D Ethene and methanol
1.4 The structures of four organic compounds are shown below.

Which of the above compounds have the same IUPAC name?

A I and II only  
B III and IV only  
C I and III only  
D II and IV only  

(2)

1.5 Which ONE of the following homologous series does NOT contain a CARBONYL group ( -C=O )?

A Aldehydes  
B Alcohols  
C Carboxylic acids  
D Esters  

(2)
1.6 The structural formula of an organic compound is given below.

```
CH₃
\-CH-CH-CH₂- \-C≡C- \-CH₃
\-CH₃
```

The IUPAC name of this compound is ...

A  2,3-dimethylhept-5-yne.
B  5,6-dimethylhept-2-yne.
C  2,3-methylhept-2-yne.
D  5,6-dimethylhept-3-yne.

(2)

**Question 2 (Adapted from Nov 2011, NSC, P2, Question 3)**

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

```
A | B
---|---
```
```
\( \text{H}_3\text{C-CH-CH-OH} \)
\( \text{H} \)
\( \text{H} \)
\( \text{H} \)
\( \text{H} \)

\( \text{H}_3\text{C-C≡C-CH}_3 \)
\( \text{H} \)
\( \text{H} \)
```
```
C | D
---|---
```
```
\( \text{CH}_2-\text{CH}_2 \)
\( \text{CH}_2 \)

\( \text{H} \)
\( \text{H} \)
\( \text{H} \)
\( \text{H} \)
\( \text{H} \)
```
```
E | F
---|---
```
```
```
\( \text{HCCCH} \)
\( \text{H}_3\text{C-CH-CH-OH} \)
\( \text{H}_3\text{C-C≡C-CH}_3 \)
\( \text{H} \)
```
```
```
```
```
\( \text{HCCCH} \)

\( \text{ethyl butanoate} \)
```
```
2.1 Write down the letter that represents the following:

2.1.1 A ketone (1)

2.1.2 A compound which is an isomer of prop-1-ene (1)

2.2 Write down the IUPAC name of the following:

2.2.1 Compound A (2)

2.2.2 Compound B (2)

2.3 Write down the NAME or FORMULA of EACH of the TWO products formed during the complete combustion of compound E. (2)

2.4 Compound F is the organic product of the reaction between a carboxylic acid and ethanol. Write down the following:

2.4.1 The name of the homologous series to which compound F belongs (1)

2.4.2 The structural formula of the FUNCTIONAL GROUP of carboxylic acids (1)

2.4.3 The IUPAC name of the carboxylic acid from which compound F is prepared (2)

2.4.4 The structural formula of compound F (2)

Question 3 (Adapted from Nov 2011, NSC, P2, Question 4)

Three hydrocarbons (A, B and C) with molecular formula C₅H₁₂ are used to investigate the effect of BRANCHING on the BOILING POINTS of hydrocarbons. The results obtained are shown in the table below.

<table>
<thead>
<tr>
<th>HYDROCARBON</th>
<th>BOILING POINT (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>36</td>
</tr>
<tr>
<td>B</td>
<td>28</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
</tr>
</tbody>
</table>

3.1 Write down the term used to describe compounds with the same molecular formula, but with different structural formulae. (1)

3.2 Write down for this investigation the following:

3.2.1 Dependent variable (1)

3.2.2 Independent variable (1)

3.2.3 Controlled variable (1)

3.3 Are these hydrocarbons saturated or unsaturated? Explain the answer. (3)
3.4 One of the hydrocarbons (A, B or C) has a straight chain with no branches. Write down the following:

3.4.1 The letter (A, B or C) that represents this hydrocarbon (1)

3.4.2 Its IUPAC name (2)

3.5 Consider hydrocarbon C and its boiling point.

3.5.1 Write down the structural formula of hydrocarbon C. (2)

3.5.2 Explain why hydrocarbon C has the lowest boiling point. In your explanation, refer to its structure, intermolecular forces and the energy involved. (3)

3.6 Which ONE of hydrocarbons (A, B or C) has the highest vapour pressure? Refer to the data in the table to give a reason for the answer. (2)
ORGANIC REACTIONS

STUDY NOTES

Combustion reactions:
- Hydrocarbons react with oxygen to form water and carbon dioxide and energy.
- Alkane example: \[2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O}\]
- Alkenes and Alkynes undergo similar reactions to form the same products.

Substitution reactions
- An atom or group of atoms in a molecule is substituted by another.
- One atom or group is removed and another takes its place.
  E.g. 1 \[\text{CH}_4(\text{g}) + \text{Br}_2(\text{g}) \rightarrow \text{CH}_3\text{Br}(\text{g}) + \text{HBr}(\text{g})\] Halogenation
  E.g. 2 \[\text{CH}_3\text{Cl}(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CH}_3\text{OH}(\text{aq}) + \text{HCl}(\text{aq})\] Hydration

Addition reactions
- Reverse of elimination reactions.
- The number of molecules decreases in addition reaction (on product side).
- High T favour elimination reactions and low T favour addition reactions.
- Therefore, we can drive reactions in opposite paths.
- Addition reactions generally occur faster than substitutions reactions.
  E.g. \[\text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{g})\]

Elimination reactions
- Molecule of a reactant breaks up to form 2 or more new molecules
- Opposite of addition reactions.
- Number of molecules greater on product side.
- Single bond is ELIMINATED and double bond forms!
  E.g. 1 \[\text{C}_2\text{H}_5\text{OH}(\text{g}) + \rightarrow (\text{conc. acid + heat}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{l}) + \text{H}^+\]
  Dehydration is the elimination of the hydroxyl (-OH) and the H atom from the alcohol.
  E.g. 2 \[\text{C}_2\text{H}_5\text{Cl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})\]
  Dehydrohalogenation is the elimination of the halogen atom (Cl) and an H atom leaving a carbon = carbon bond – strong base is used.
Cracking

- Heating to a high temperature
- Produces unsaturated products
  E.g. $\text{CH}_3\text{CH}_3 \rightarrow \text{CH}_2 = \text{CH}_2 + \text{H}_2$

Oxidation

- Alcohols for example can also undergo oxidation.
- Oxidation of a primary alcohol: $\text{K}_2\text{Cr}_2\text{O}_7$ as catalyst – forms an aldehyde.
- Oxidation of a secondary alcohol: $\text{K}_2\text{Cr}_2\text{O}_7$ as catalyst – forms a ketone.

**Question 1 (Adapted from Nov 2011, P2, Question 5)**

In the flow diagram below, R, P and Q represent different types of reactions.

1.1 Name the type of reaction represented by:
   1.1.1 P  
   1.1.2 Q  
   1.1.3 R

1.2 Using structural formulae, write down a balanced equation for reaction P.  

1.3 Write down the IUPAC name of alcohol Y.

1.4 Reaction Q takes place in the presence of a BASE. Write down TWO reaction conditions for this reaction.
**Question 2** (Adapted from Feb/Mar 2011, P2, Question 5.1 & 5.2)

Prop-1-ene, an UNSATURATED hydrocarbon, and compound X, a SATURATED hydrocarbon, react with chlorine, as represented by the incomplete equations below.

**Reaction I:**  \[ \text{Prop-1-ene} + \text{Cl}_2 \rightarrow \]

**Reaction II:**  \[ \text{X} + \text{Cl}_2 \rightarrow 2\text{-chlorobutane} + \text{Y} \]

2.1.1 Give a reason why prop-1-ene is classified as unsaturated.  

2.1.2 What type of reaction (ADDITION or SUBSTITUTION) takes place in the following:

(a) Reaction I  
(b) Reaction II  

2.1.3 Write down the structural formula of the product formed in Reaction I.  

2.1.4 Write down the reaction condition necessary for Reaction II to take place.  

2.1.5 Write down the IUPAC name of reactant X.  

2.1.6 Write down the name or formula of product Y.  

2-chlorobutane can either undergo ELIMINATION or SUBSTITUTION in the presence of a strong base such as sodium hydroxide.

2.2.1 Which reaction will preferably take place when 2-chlorobutane is heated in the presence of CONCENTRATED sodium hydroxide in ethanol? Write down only SUBSTITUTION or ELIMINATION.  

2.2.2 Write down the IUPAC name of the major organic compound formed in Question 2.2.1.  

2.2.3 Use structural formulae to write down a balanced equation for the reaction that takes place when 2-chlorobutane reacts with a DILUTE sodium hydroxide solution.  

2.2.4 Write down the name of the type of substitution reaction that takes place in Question 2.2.3.
Hexanoic acid is responsible for the unique odour associated with goats. When it reacts with alcohol X, ethyl hexanoate, which is used commercially as a fruit flavour, is formed.

Learners set up the apparatus shown below to prepare ethyl hexanoate in a laboratory.

3.1 Write down the IUPAC name of alcohol X. (2)

3.2 What is the role of the sulphuric acid in the above reaction? (1)

3.3 Use structural formulae to write down a balanced equation for the preparation of ethyl hexanoate. (6)

3.4 Give a reason why the test tube and its contents are heated in a water bath and not directly over the flame. (1)

3.5 Write down ONE use of esters in the food manufacturing industry. (1)
RATES OF REACTION

STUDY NOTES

HEAT OF REACTION (ENTHALPY)

- Heat of the reaction (\(\Delta H\)) is the difference between the energy of the products and the energy of the reactants.
  \[ \Delta H = E_{\text{products}} - E_{\text{reactants}} \]
- For an **endothermic reaction**, \(E_{\text{products}} > E_{\text{reactants}}\), therefore, \(\Delta H\) is positive.

Note: In a reversible reaction, the energy released in forming the products in the forward reaction is the same as the activation energy (\(E_A\)) of the reverse reaction.

- For an **exothermic reaction**, \(E_{\text{products}} < E_{\text{reactants}}, \Delta H\) is negative.
RATES – SPEED OF A REACTION

When we study the rate of the reaction, we study the speed at which the reaction occurs.

Macroscopic vs Microscopic

It is important to know that no one has ever seen an atom and it is very unlikely that anyone will see an atom in the near future. What we see in chemical reactions is known as MACROSCOPIC observations. What is actually happening to the atoms, we refer to as MICROSCOPIC changes. Often MICROSCOPIC changes are just THEORY.

Collision Theory

- Reactions take place when particles collide.
- Not all collisions lead to reactions.
- Those collisions that do lead to reactions are called effective collisions.
- To increase the rate of a reaction, the number of possible effective collisions should be increased.

In other words, the more often we can make atoms collide, the faster the reaction will take place.

Factors that Influence Rate

- **Temperature** – The faster the particles move, the more likely they are to collide, so the more likely they are to react.
- **Pressure** (only in gases) – The more you push the particles together, the more likely they are to collide, so the more likely they are to react.
- **Concentration** (solutions and gases) – the more particles squashed in per dm$^3$, the more likely they are to collide, so the more likely they are to react.
- **State of division and size of reaction surface** (solids) – the more particles open to be reacted with, the more likely they are to collide, so the more likely they are to react.
- **Catalyst** – the activation energy is lowered for the reaction making it easier for substances to react, so they react faster.
- **Nature of reacting substances** – different types of substances, by their very nature, react at different speeds. For example, iron oxidises (rusts) relatively slowly while carbon (coal) oxidises (burns) fairly fast.

Measuring Reaction Rate

If we do an experiment to establish the speed (rate) of a reaction under different conditions, we can measure how fast the reaction is proceeding in a number of different ways:

- how reactants disappear or products appear
- colour changes (colour cards or spectrophotometers)
- concentration of ions (conductivity)
- gas volume produced
- mass changes
- volume of solid formed
Catalysts

- A catalyst is a substance that speeds up a chemical reaction without being chemically changed itself. It does not form part of the product.
- Catalysts make it possible for reactants to enter a new transition state that has less potential energy. (Lower activation energy)
- Catalysts provide a new MECHANISM for the reaction.
- The reaction mechanism is the sequence of events at a molecular level that control the speed and outcome of a reaction.

Types of Catalysts

- Heterogeneous – usually solid with gas or liquid moving over it (motor vehicle catalytic converters)
- Homogeneous – usually all in the liquid phase
- Enzymes – very specific shaped biological molecules (lock and key mechanisms)

RATES OF REACTION QUESTIONS

Question 1 (Adapted from November 2011 P2, Question 9)

Study the following reactions

a.  \( X + Y \rightarrow R + S \) \( \Delta H = -200 \text{ kJ mol}^{-1} \) Activation energy for the reaction 350 kJ mol\(^{-1}\)

b.  \( C + D \rightarrow E + F \) \( \Delta H = 150 \text{ kJ mol}^{-1} \) Activation energy for the reaction 600 kJ mol\(^{-1}\)

1.1 Are the above reactions endothermic of exothermic? Explain. (4)

1.2 What is meant by the term activation energy? (2)

1.3 From the information supplied, what can we deduce about the rate of the reactions? Explain. (5)

1.4 What can be done to reduce the amount of activation needed in a reaction? (2)

Question 2 (Adapted from November 2011 P2, Question 6)

Learners use copper(II) oxide POWDER to decompose hydrogen peroxide. They add 1 g copper(II) oxide to 100 cm\(^3\) hydrogen peroxide in a flask connected to a delivery tube. The reaction that takes place is represented by the following balanced equation:

\[
2\text{H}_2\text{O}_2(\ell) \xrightarrow{\text{CuO(s)}} 2\text{H}_2\text{O}(\ell) + \text{O}_2(g)
\]

2.1 Write down the name of ONE item of apparatus that can be used to measure the volume of the gas produced. (1)
The volume of oxygen gas produced is measured every 10 seconds. The results obtained are shown in the graph below.

2.2 Use the graph to determine the volume of oxygen gas collected in the container at 15 seconds.

2.3 How does the rate of the reaction change between t = 40 s and t = 70 s? Write down only INCREASES, DECREASES or REMAINS THE SAME. Refer to the graph to explain the answer.

2.4 What is the function of the copper(II) oxide in this reaction?

2.5 Apart from oxygen, write down the NAMES or FORMULAE of TWO substances present in the flask after 90 seconds.

2.6 The learners found that oxygen is produced at a slower rate when 1 g of a SOLID LUMP of copper(II) oxide is used. Fully explain this observation.

2.7 It is known that bad breath is due to bacterial activity in the mouth in the absence of oxygen.

Use the reaction above to explain why a solution containing hydrogen peroxide can be used as mouthwash to improve bad breath.

[12]
Question 3

A catalyst speeds up the rate of a reaction. This behaviour of a catalyst can be explained in terms of the activation energy and the collision theory.

3.1 The diagram above shows the Maxwell-Boltzmann distribution curve for a certain reaction.

3.1.1 Explain in terms of the collision theory and activation energy, how a catalyst influences the rate of reaction. (4)

3.1.2 Redraw the above distribution curve into the answer book, and show the new activation energy when a catalyst is added to the reaction mixture on the diagram. (2)

3.2 When milk is left at room temperature, it spoils rapidly. However, in a refrigerator, it stays fresh for a longer time. Use the collision theory to explain this observation. (3)