

Science lessons for Grade 11

Lessons in this section

Biology

- 1 Homologous chromosomes

Chemistry

- 2 Alkenes
- 3 Acid–carbonate titration (Grade 11 Advanced, Grade 12 Foundation)

Physics

- 4 Half-life (Grade 11 Advanced, Grade 12 Foundation)

Resource sheets for the lessons

Using these lesson plans

These sample lessons for Grade 11 are suitable for use with a whole class. The lessons are single examples to illustrate different teaching and learning activities. They are not intended to be taught as a sequence. They are drawn from different topics and points in the teaching year to show spread rather than sequence.

The objectives for the lessons are drawn from the advanced standards for Grade 11 and the foundation standards for both Grades 11 and 12. The relevant standards are shown in the lesson plans. All lessons are suitable for students following the foundation programme but incorporate additional material suitable for those who will ultimately study the subjects at the advanced level.

The lesson plans indicate any safety issues relevant to the lessons. They also provide equipment lists and any short- and long-term preparation required by the lessons. Some of the plans include notes that provide additional information relevant to the teaching of the lesson that may not be readily accessible elsewhere.

Most of the lessons are organised in three parts: an introduction to the lesson, a main activity, and a final phase to help students to reflect on the lesson and consolidate their learning. As part of the introduction, you should outline the purpose of the lesson, drawing out for students what they will learn and how this builds on previous work. In the final part of the lesson, you will need to establish the key learning points, what students need to remember and what they will go on to learn next. There is no expectation that students should copy out the key learning points in their exercise books.

Most of the lesson plans do not include homework tasks because the lessons are single examples taken out of sequence. You will need to provide this, since homework is an important part of a lesson.

The lesson plans have enough material to support a minimum of about 60 minutes of teaching. You may need to supplement the activities with simpler or more challenging tasks if the students in your class have a range of attainment. You could choose from activities in textbooks or from your own resources. If you wish, different tasks can be given to different groups of students, according to their needs.

For some classes there may be too much material in the lesson plan for 60 minutes. In this case, you could designate one of the activities in the lesson as homework, or carry it forward to the next lesson. Be selective about which activity to cut – it does not have to be the last one merely because it comes at the end.

Lesson plan 11.4 'Half-life' is a demonstration lesson to be done by the teacher. It involves the use of radioactive materials and should not be attempted by teachers who have not had approved training in their use.

11.1

Homologous chromosomes

Objectives

- Explain the significance of organisms having a set of homologous chromosomes.
- Use an appropriate range of methods to communicate scientific information.

This lesson is suitable for both foundation and advanced students.

Preparation

You will need some prepared microscope slides that show chromosomes in a cell (available from educational suppliers) and a suitable microscope with which to view these. A projection microscope would allow all the class to view the same slide together. Alternatively, you could use photographs or projection transparencies of chromosomes. Each student will need a copy of Resources 11.1a and 11.1b and access to scissors and glue.

Introduction

Vocabulary
chromosome

Chromosomes

Start this lesson by asking students about chromosomes. Establish their knowledge and understanding by asking questions such as:

- Q Where would you look for chromosomes?
- Q What important molecules are carried on chromosomes?
- Q What is the function of chromosomes?
- Q How many chromosomes do you have in the cells of your body?
- Q If somatic cells have $2n$ chromosomes, how many do sex cells have?

It is important to establish that students know that chromosomes carry DNA, the genetic material, and that the sex cells have half the number of chromosomes of the somatic cells.

Explain to the class that the lesson is concerned with the structure, function and behaviour of chromosomes.

Main activity

Vocabulary
homologous

Resources
Microscope
Prepared slides of chromosomes
Photographs of chromosomes
Scissors
Glue or sticky tape
Resources 11.1a and b

Chromosomes

Activity 1 Looking at chromosomes

In this part of the lesson students should examine chromosomes. Ideally this should be a microscope study of prepared slides (an oil immersion lens is needed). A projection microscope would allow all the class to see the slides and discuss their observations. If this is not possible, then photographs should be used. You could download these from the Internet if they are not available elsewhere. The purpose of the activity is for students to appreciate the small size of chromosomes (they are contained within the nucleus) and to recognise that because chromosomes are different in size and appearance they can be recognised individually.

Activity 2 Identifying homologous pairs of chromosomes

Issue individual students with **Resources 11.1a** and **11.1b**, scissors and some glue or sticky tape. Explain to students that they have been given sets of chromosomes from each of two members of the same species. They should work with each chromosome set in turn and try to sort the chromosomes into groups that are the same. They should find that one set has ten pairs of chromosomes and the other nine pairs and two chromosomes that do not pair. Tell the class that the paired chromosomes are called *homologous pairs*.

Activity 3 Why homologous pairs?

In this part of the lesson you will need to explain to students the significance of there being homologous pairs of chromosomes. You could start by asking questions such as:

- Q If chromosomes look exactly the same, what might that tell you about the genes they carry?** (they are the same)
- Q What happens to the number of chromosomes when somatic cells divide?** (the chromosome number is conserved as $2n$)
- Q What happens to the number of chromosomes when sex cells are formed?** (the number is halved to n)
- Q How might homologous pairs of chromosomes behave when sex cells are formed?** (one goes to each sex cell)
- Q How is the chromosome number changed when sex cells combine?** (it is restored to $2n$)

The important point to get across to students is that because homologous chromosomes carry the same genes in the same positions, a full set of the genes goes into each sex cell, and when the sex cells combine in reproduction, a double set of genes is created in the somatic cells of the new organism. Reproduction does not result in the loss or multiplication of genetic material.

Activity 4 Genes and alleles

Encourage students to consider their knowledge and understanding of genetics. Ask them about genes and alleles and dominant and recessive features. Possible questions include:

- Q What is the difference between a gene and an allele?** (a gene determines a feature and an allele determines the form of the feature)
- Q If the same gene is carried on both chromosomes of a homologous pair, what would be the effect if the alleles were the same?** (all the progeny would inherit the same allele)
- Q If the same gene is carried on both chromosomes of a homologous pair, what would be the effect if the alleles were different?** (the progeny would have an equal chance of inheriting one or other of the alleles)

Responses should be used to establish that because the pairs of homologous chromosomes carry the alleles of the same genes and they segregate to different sex cells, this creates the possibility of variation. You should also bring out that the fact that because cells have homologous pairs of chromosomes we can explain the possession of dominant and recessive alleles by the same individual. One chromosome of the homologous pair has one allele and the partner chromosome has the other allele.

Activity 5 Non-homologous chromosomes

Ask students to return to the chromosomes they cut out of the resource sheets. They had one set that formed ten homologous pairs and one set that had nine pairs and two unpaired chromosomes. Ask the class to see if any of the two unpaired chromosomes matches any of the ten sets of paired chromosomes. They should find that one does. They should also find that all the other pairs match up too.

Explain that they have been working with a subset of chromosomes representing the complement of human chromosomes ($2n = 46$). The set with the unpaired chromosomes represents a male and the other set represents a female.

Tell the class that females have a complete matched set of chromosomes – all homologous pairs – but males have two unmatched chromosomes. One of these is the same as a female chromosome and the other is unique. It is the possession of these chromosomes that determines if one is male or female.

Round off this section of the lesson by stressing that homologous chromosomes carry the same genes and that each member of the pair may or may not carry the same alleles. Make clear to students that because only one of each homologous pair goes to a sex cell, genetic material is conserved in reproduction, and because each chromosome, and thus each allele, has an equal chance of being in a sex cell and combining with another sex cell, genetic variation occurs.

Consolidation

Draw a diagram of two different chromosomes on the left-hand side of the board. On the right-hand side of the board draw six other chromosomes and make two of these identical to the two drawn on the left-hand side (this could also be done on an OHP transparency). Ask students to identify the homologous pairs of chromosomes. Now mark on one of each pair of homologous chromosomes the position of various genes that you decide are carried on the chromosome. Ask students to come out and mark the position of the same genes on the homologous chromosomes.

Try to involve several students in this final activity and encourage participation by the more reluctant or weaker members of the class.

Other tasks

Students could be asked to find out the number of chromosomes in the cells of some organisms and whether all of these form homologous pairs.

Summary for students

- The nucleus of a cell contains chromosomes.
- Chromosomes contain DNA, which is the constituent of genes.
- Organisms tend to have homologous pairs of chromosomes.
- Homologous pairs of chromosomes are identical in form and carry the same genes.
- Homologous pairs of chromosomes may have the same or different alleles of the same gene.
- Individual chromosomes of a homologous pair segregate to different sex cells.
- The combination of sex cells in reproduction restores the normal somatic cell chromosome number.
- The segregation and combination of homologous chromosomes accounts for genetic variation.
- Some organisms (such as humans) have a pair of non-homologous chromosomes. These are usually associated with sex determination.

Notes

This lesson is best done after students have consolidated their understanding of basic genetics.

11.2

Alkenes

Objectives

- Know that petroleum and natural gas are sources of organic compounds.
- Describe the processes of catalytic cracking and gas-to-liquid refining.
- Describe the chemistry of alkenes as the chemistry of the double bond, exemplified by addition reactions.

This lesson is suitable for both foundation and advanced students.

Preparation

Obtain brochures and other materials, such as pictures and posters, related to gas-to-liquid processes being developed in Qatar.

Ensure that the equipment is made up correctly, particularly the delivery tube and bung. Make fresh limewater within a day of the lesson. Practise the experiment if it is unfamiliar.

Safety

This experiment carries a small fire risk. The usual precautions, such as the ready availability of a fire blanket and extinguisher, should be taken. Eye protection should be worn.

Introduction

Ask questions to get students to recall the chemistry, uses and origins of the alkanes from the previous lesson:

Q What are the main uses of the alkanes?

Q Where do we get alkanes from?

Q How are the alkanes suitable for fuel obtained from crude oil?

The point of this questioning is to establish that the main use of alkanes is as fuel for vehicles and that crude oil must be refined to provide this. Remind students that the heavier fractions can be broken down by ‘cracking’ into more useful lighter oils. There are two ways of doing this. One, most commonly used in industry, is to use moderate heat and a catalyst. Another is to use strong heat, as in the following activity.

Main activity

Resources (per group)

Liquid paraffin
Mineral wool
Bits of broken pot
Bunsen burner
Spills
Beaker
Access to bromine water,
0.5 M acidified potassium
manganate (VII) solution
and fresh lime water
Dropping pipette
10 test-tubes in a rack
and corks
Bung and delivery tube
Resource 11.2

Cracking large alkanes

Students should work in groups of up to four. Time: a double period.

Give out **Resource 11.2**. Supervise the setting up of the equipment, helping where necessary. Do not allow groups to start heating until their equipment has been inspected. Demonstrate the process briefly with one of the sets. Use a hot flame and ensure that the pot is red hot next to the flame.

Remind the class not to collect the first tube of gas as this will be air that has expanded in the heating tube.

Also remind them not to stop heating at any time as this will result in water being sucked into the hot tube, breaking it.

Groups should collect several tubes of the gas. They may need assistance with inverting the tubes full of water in the beaker. They will probably spill water on the

bench; have cloths ready. The full tubes should be tightly corked and put in the rack.

Supervise the tests. Students should set fire to the gas with a burning spill, not the Bunsen burner. Encourage them not to use more of the reagents than they need to see the result. A few drops only are needed.

Consolidation

After clearing away the equipment, bring the class together to discuss the results. Have some tubes of ethene ready to repeat the tests to ensure they have seen them.

The detailed chemistry of the double bond should be left for the next theory lesson. The remainder of this lesson should be spent making sure students fully understand that the process is one of breaking large molecules into smaller ones.

Q Which molecules were smaller, the starting paraffin molecules or the product?

The answer is the product molecules.

Q How do we know this?

Because the product is a gas and gas molecules are smaller than molecules of liquids.

Q Why is this process useful?

Because we have more uses for hydrocarbons that have smaller molecules than those that have large molecules.

Now consider the Qatar gas field. Students will know that this consists mainly of methane, which is not very useful because the methane molecule is too small. To make it useful the methane must be made into larger hydrocarbons that are liquid. This is the opposite problem from the one that they have just investigated.

Other tasks

For homework students could be asked to investigate the processes being set up by many companies (Orxy Fuels, QP/ExxonMobil and QP/Marathon Oil) to convert gas to liquid fuels. These are called GTL processes. Students should have access to company brochures explaining the process. Advanced students should be asked to try to summarise the process in a flow chart.

Summary for students

- Ethene can be made by the thermal decomposition of liquid alkanes.
- Breaking up large hydrocarbons to make smaller ones is called 'cracking'.
- Ethene reacts with bromine and with acidified potassium manganate (VII) solution, decolourising them.
- GTL processes in Qatar are being set up to make liquid hydrocarbons from methane.

11.3

Acid–carbonate titration

Objectives

- Determine the concentrations of reactants in solutions through acid–base titrations with appropriate indicators.
- Draw valid conclusions, allowing for errors and uncertainties.
- Select and use correctly and competently the appropriate equipment and materials for an investigation, with due regard for the safety of self and others.
- Follow instructions accurately.

This lesson is suitable for both Grade 11 advanced students and Grade 12 foundation students.

Preparation

Purchase a supply of commercially available baking powder and carry out the titration in Resource 11.3 to determine whether the quantities suggested are appropriate for your baking powder. If they are not, alter the quantities appropriately.

Ensure that all volumetric equipment is clean and that enough pipette fillers are available.

Note that males with red–green colour-blindness will find the methyl orange end-point difficult to determine. It is useful to have examples of solutions that are acid, alkaline and at the end-point available as standards for comparison. These should be prepared immediately before the lesson.

Safety

Although none of the solutions used in this titration is harmful, it is inadvisable to fill pipettes using the mouth. Pipette fillers should be available.

Introduction

Resources (per class)

Supplies of distilled water,
0.1 M hydrochloric acid
and baking powder

Access to an accurate
balance

Methyl orange indicator
solution in dropping
bottle

This lesson assumes that students already have received some basic instruction on the techniques of volumetric analysis. Students should know how to use a volumetric flask, burette and pipette (with a pipette filler) and how to determine an end-point. They should be familiar with the methyl orange end-point.

Question the class to help them recall the acid–carbonate reaction. Take the questions further to show that the solution at the end-point will be acidic because of the presence of dissolved carbon dioxide.

Q What happens when an acid is added to a carbonate?

Q How can we tell when all the carbonate has been neutralised by the acid?

Q What will the pH of the solution be at the end-point? Why will it be this pH?

Q What indicator should we use to indicate this end-point?

Introduce some commercial baking powder. Ask a student to read the contents on the label. Mix some of it with some acid and show the reaction. Show that the powder does not fully dissolve in water (baking powder contains flour, which is insoluble in cold water).

Q How could we find out how much of this baking powder is sodium hydrogen carbonate?

Some students will suggest a titration with acid. Then ask about how to deal with the problem of the insoluble flour. Some may suggest filtration. Get them thinking about the process of the analysis. Construct, with them, a flow chart of the process on the board.

Q When should we filter it? Before or after we weigh out a sample for analysis?

The flow chart will be:

weigh sample – make up to known volume with water – shake with water to dissolve – filter – titrate filtrate.

Main activity

Resources (per pair)

3 × 250 cm³ conical flasks
250 cm³ volumetric flask
with stopper
250 cm³ beaker
50 cm³ burette
25 cm³ pipette and filler
Distilled water wash bottle
Glass filter funnel and
filter paper
Resource 11.3

Determining the concentration of sodium hydrogen carbonate in a sample of baking powder

Students should work in pairs. Time: about 45 minutes.

Give out the equipment and a copy of **Resource 11.3** to each pair.

Ask students to work through the instructions on Resource 11.3.

Circulate giving assistance where necessary. Alternatively, this lesson could be considered as a practical assessment, in which case either minimal assistance is given or, where it is, marks are deducted from the assessment grade.

Allow sufficient time to clear away the equipment used in this activity.

Consolidation

If the lesson was not used for assessment purposes, bring the class together to:

- identify and respond to difficulties they have had with the work;
- go through the calculation using one set of results.

If the classwork is being assessed, postpone the consolidation to the next lesson, collect in the assignment and mark it to the criteria suggested in notes below.

Summary for students

- Acid-carbonate titrations are carried out using methyl orange as indicator.
- Students should be able to use the glassware involved in volumetric analysis.
- Percentage purity is calculated by dividing the mass of the pure substance found by analysis by the mass used and multiplying by 100.

Notes

Assessing skills

This work involves a number of skills. Skills should be assessed from time to time. They should be assessed using clear assessment criteria that can be justified. It is not easy to write criteria for 10 marks; a simple method is to mark out of 5 and have defined criteria for 1, 3 and 5 marks. The intervening 2 or 4 marks can be awarded where there is doubt that the solution fully justifies the criteria for 3 or 5 marks. An example is shown below.

Skill: Using volumetric analysis equipment correctly

The correct use of the equipment can be inferred from the results obtained. The teacher must carry out the experiment twice using the materials that the students use and both results should agree. The overall result for the percentage purity is compared with the student result after the student's calculations have been checked.

- | | |
|---------|---|
| 1 mark | More than 5% disagreement with the teacher's result. |
| 3 marks | Between 1% and 5% disagreement with the teacher's result. |
| 5 marks | Within 1% of the teacher's result. |

11.4

Half-life

Objectives

- Understand the spontaneous and random nature of nuclear decay.
- Interpret decay data in terms of half-life.
- Explain the source of the background radiation.

This lesson is suitable for both Grade 11 advanced students and Grade 12 foundation students.

Safety

Radioactive materials are used in this lesson. They must be licensed for use in schools and are safe when used according to the guidelines supplied with them. They should not be used by teachers who have not had training in the handling of radioactive materials and teachers must be aware of regulations governing their use that may be established by the government of Qatar.

The materials described in this lesson do not contribute detectably to the classroom background radiation 1 m from the source and are short-lived isotopes that decay to undetectable levels after an hour.

Introduction

Vocabulary

decay
eluent
fallout
half-life
isotopes

This is a demonstration lesson. All demonstrations must be practised beforehand to identify problems and ensure correct timing. You should develop a good demonstration technique that involves the following:

- The demonstration desk must be clear of all superfluous material.
- Students should be at least 2 m from the demonstration desk.
- You should be able to walk right round the demonstration desk unhindered by students.
- The equipment on the desk should be set up so that its position corresponds, for students, to the position of the equipment shown in any pictures in the student material or on the blackboard. This means that, to the teacher behind the desk, the equipment is set up the opposite way round.
- You must be able to carry on a continuous lively commentary, if possible in the form of a dialogue with the class, throughout the demonstration. The commentary should describe what is being done and why.
- It is often desirable to give individual students roles in demonstrations (e.g. taking readings, writing readings on the board). This can be done in this experiment as long as safety rules are observed – students should not be within a metre of the equipment.

Students will be familiar with:

- the three types of radiation and their penetrating power;
- background radiation, what causes it and how to deal with it when taking results;
- the use of the Geiger counter;
- the concept of radioactive decay – they should have performed a simulation experiment that includes plotting a decay curve.

Question the class to remind them about the nature of background radiation and how we deal with it in experiments. Switch on the counter and ask questions like:

- Q Why is the counter registering radiation?
- Q How can we count this radiation?
- Q What causes this radiation?
- Q Is it harmful?
- Q Why must we count this radiation if we are doing radioactivity experiments?

The question about whether it is harmful can be developed to include a discussion on radioactive fallout from atomic explosions, such as those at Hiroshima and Nagasaki, from nuclear testing and from accidents, such as the one at Chernobyl in Ukraine.

This discussion can then lead to the idea of radioactive decay; the fallout from accidents gets less over time. This lesson will study the decay of a short-lived isotope. (For more details see the notes at the end of this lesson plan.)

Main activity

Resources

Geiger counter
Equipment kit for demonstrating half-life
Resource 11.4

The half-life of barium-137

Determine the background count per minute at least three times and take an average.

The teacher demonstration is described in **Resource 11.4**.

Students can be involved in recording the reading of the Geiger counter after each minute. The counter is reset after each minute so this reading must be taken quickly and written down. You will not be able to see the counter and will rely on the students. One student should write down the counts in a prepared table on the board and also subtract the background count from the raw count. About eight 1-minute counts should be taken.

The demonstration should include the clearing up process at the end.

Ask students to return to their desks and plot the decay curve in their books. The time axis should extend to 10 minutes.

Plot the curve on the board too, but only when most students have almost done it in their books. Remind them how to calculate the half-life of the isotope. Ask them to make several different calculations, starting with a different initial count each time. Ask questions about the curve, starting with simple ones and working up to complex ones.

- Q What happens to the level of radioactivity over time?
- Q How long does it take to decay to half its initial value?
- Q How long does it take to decay from half its initial value to half this value (i.e. a quarter of its initial value)?
- Q Why is the half-life always the same no matter what the initial count is?
- Q How long will the sample take to decay until we can no longer detect it?
- Q How long will the sample take to decay completely?

This final question is a difficult one. The simple answer is an infinite time (which is mathematically different from 'never') and you could introduce the idea of an exponential curve: one that approaches the x-axis but only reaches it at infinity. Bright students may envisage the situation where only one undecayed atom is left and ask how long it will be before it will decay. At this point the idea of probability

can be introduced: there is a 50:50 chance that it will have decayed after another half-life.

Consolidation

Discuss some of the implications of half-life. This could be done in many ways, perhaps starting with a picture of Chernobyl now – an uninhabited ghost town. Such resources are available on the Internet.

A distinction should be drawn in the discussion between the treatment of highly active short-lived isotopes that are very dangerous for a short period (tens of years) and long-lived ones that are less active, but still dangerous and require secure storage for many thousands of years.

The issue of the storage of long-lived isotopes can lead to a discussion of the advantages and disadvantages of nuclear power.

Summary for students

- The half-life of an isotope is the time for it to decay to half a given level of activity.
- Isotopes vary greatly in their half-life from fractions of a second to millions of years.
- The storage of long- and short-lived isotopes presents different but difficult problems.
- Nuclear power has its advantages and disadvantages.

Notes

Different ways of measuring half-life

All experiments for measuring half-life involve the collection of a short-lived daughter isotope of a long-lived isotope. The long-lived one is a sealed source. The short-lived one can diffuse away from the surface of the sealed container and be collected for analysis. There are three common ways of doing this, and purpose-made equipment kits are available for all these procedures:

- The daughter collects in an organic liquid layer above an aqueous layer that contains the parent isotope. The two layers are sealed in the same bottle and the counter is placed next to the organic layer after the mixture has been shaken.
- The daughter isotope is extracted by passing water over the surface of the sealed parent isotope. The daughter isotope is studied in the water. Resource 11.4 describes this.
- The daughter is an isotope of the gas radon that is collected by placing the sealed source in an impermeable bag for some time before the experiment. The radon in the bag is studied.

In all cases the activity of the sealed parent isotope is within the limits internationally prescribed for use in schools.