YEARS 11&12

PHYSICAL SCIENCES

TEACHING & LEARNING SUPPLEMENT

INDEPENDENT SCHOOLS TASMANIA

TASMANIAN CATHOLIC education office

Tasmanian Government

Teaching and Learning Supplement
PHYSICAL SCIENCES (PSC315118)

ADVICE FOR TEACHERS

This document helps to describe the nature and sequence of teaching and learning necessary for learners to demonstrate achievement of course outcomes.

It suggests appropriate learning activities to enable learners to develop the knowledge and skills identified in the course outcome statements.

Tasks should provide a variety and the mix of tasks should reflect the fact that different types of tasks suit different knowledge and skills, and different learning styles. Tasks do not have to be lengthy to make a decision about learner demonstration of achievement of an outcome.

COURSE SPECIFIC ADVICE

This *Physical Sciences level 3* Teaching and Learning Supplement must be read in conjunction with the *Physical Sciences level 3* course document and relevant External Assessment Specifications and Examination Guidelines.

It contains advice to assist teachers delivering the course and can be modified as required. This Teaching and Learning Supplement is designed to support teachers new to or returning to teaching this course. The practical component of this course may include off campus experiences.

For the content areas of *Physical Sciences*, three interrelated strands - *Science Inquiry Skills; Science as a Human Endeavour;* and *Science Understanding* will be integrated into all sections of study.

Science Inquiry Skills are common to all TASC science courses and are contextualised for each discipline.

Practical investigation, interpretation of data and reflecting on experimental design are used as a means of teaching and consolidating the course content as well as a means of assessment.

The application and impact of physical sciences in society is also an integral part of the course.

COURSE CONTENT

Specific teaching advice is given in this supplement about of the following criteria:

	Content or process for criterion	Sequence
Criterion 2	Undertake, interpret and analyse physical science experiments	For use throughout the course in conjunction with criteria 4 to 8
Criterion 3	Analyse the impact of physical sciences on society	

	Content or process for criterion	Sequence
Criterion 4	Apply concepts and processes of atoms and nuclear reactions	Content can be delivered in any particular order
Criterion 5	Apply concepts and processes of motion and force	
Criterion 6	Apply concepts and processes of conservation in physics	
Criterion 7	Apply concepts and processes of chemical structures and properties	
Criterion 8	Apply concepts and processes of chemical reactions and reacting quantities	

Physical Sciences 3 has a complexity of TASC level 3 and a design time of 150 hours. Content is divided into five sections; relating directly to Criteria 4 to 8, respectively, in the course. The order of delivery of the content is not prescribed. Each of the five content sections is compulsory and learners must participate in a minimum of 40 hours of practical activities. Learning activities for Criteria 2 and 3 should be related to and support one or more of the five content areas.

TEACHING AND LEARNING ACTIVITIES

Undertake, interpret and analyse physical sciences experiments

Criterion 2 ***Examples of learning activities***

Learners:

investigate whether two 60 W light bulbs shine brighter than three 40 W light bulbs

develop a hypothesis then design and perform an experiment to answer a question related to projectile motion, for example:

- How does angle affect the range of a projectile?
- How does shape of projectile affect the range of a projectile?

investigate the relationship between the thickness of a crumple zone and the elasticity of a collision

investigate how the friction force depends on speed by considering the rolling of a wood puck on the wooden surface of a table

investigate practically the trends in reactivity as you go across a period in the periodic table

determine qualitatively the solubility of a variety of solid, liquid solutes in water; write equations for substances dissolving in water

perform experiments to differentiate between strong and weak acids on the basis of conductivity, pH and rate of reaction with magnesium prepare a standard solution of anhydrous sodium carbonate and use it to standardise a solution of hydrochloric acid

which brand of vinegar is best value? (based on titration)

black box – equivalent resistance – determine the combination of resistors in a black box.

efficiency of a small electric motor: compare electrical power with mechanical power by raising a weight through a known height.

Detailed example

Introduction to Acid~Base Titrations

Learners will determine, by titration, the concentration of an unknown solution of sodium hydroxide $NaOH_{(aq)}$ using a solution of hydrochloric acid, $HCl_{(aq)}$, of known concentration.

Learners:

1. wash, prepare and fill a clean burette with the unknown molarity solution of sodium hydroxide. Record the initial burette reading.
2. using a clean 20.0 mL bulb pipette, transfer 20.0 mL of the hydrochloric acid solution into a clean 250 mL conical beaker and add 4 drops of phenolphthalein indicator.
3. add $NaOH_{(aq)}$ from the burette until a pale pink colour is first observed. The colour should persist for at least 30 seconds. Record the final burette reading.
4. discard this final solution into the sink and wash out the flask with distilled water.
5. repeat steps (2)-(4) until you obtain consistent results for the end-point (ideally the readings should not vary by more than 0.2 mL)
6. record the average volume of $NaOH_{(aq)}$ solution used per titration.

Results and calculations:

Record the results in a table such as:

Final burette				
Initial burette				
Titre				

The balanced equation for the reaction occurring in this titration reaction is:

$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

- record the concentration of the hydrochloric acid solution used in the titration. Note: this solution was prepared for you by our laboratory technician!
- from the volume of hydrochloric acid used and its molarity, determine the number of mole of HCl(aq) used in each titration, i.e. find n(HCl).
- consider the balanced equation, determine the number of mole of sodium hydroxide reacting per titration; i.e. n(NaOH)

- using the average titre (volume of $NaOH_{(aq)}$ used), calculate the molarity of the sodium hydroxide solution. ie calculate [NaOH(aq)].

Discussion and conclusion

In addition to commenting on the accuracy of the concentration they found for the NaOH(aq) solution. Learners need to comment on the scope, nature and likely sources of errors. Reflecting on this they should be able to comment on ways to eliminate or mitigate against some sources of error and inherent levels of accuracy of the titration they have performed.

Analyse the impact of physical sciences on society

Criterion 3 ***Examples of learning activities***

Learners:

investigate the effectiveness of car safety features, for example, positioning of road signs, seat belts, child restraints, air bags, brakes and automatic braking systems, safe speed limits

analyse motion in a straight line by comparing how cars really perform as they are driven, compared to the model with constant acceleration etc.

compare stopping distances for different speeds (using $2as = v^2$) and determine the validity of this statement the statement '$40kmh^{-1}$ is the safest speed to travel near schools'

research the number of times bombs missed their targets in World War 2 and use projectile motion calculations to work out where they should have been released [consider the Dam Busters]

research and calculate how the angle a ball is kicked at influences the distance it travels and relate to the optimum size of sports arenas. For example: should women's sports have smaller field sizes?

discuss the features of helmets which enable them to protect riders. Explain in terms of Newton's Laws of Motion.

discuss why the total mass of passengers, luggage and fuel is important for aircraft and relate to Jetstar carry on baggage rules. Include reference to forces involved, take-off velocity and runway length. Should passenger mass influence ticket price as it does for Air Samoa?

investigate how the bounce of a table tennis ball is affected when it is partially filled with water

research:

- is living near electrical substations a health hazard?
- is flying safe?
- is medical radiation safe?
- the use of fusion and fission as sources of power and compare their viability as an energy source, consider in a Tasmanian context vs an Australian mainland context.
- the main types of nuclear reactors in use around the world today: How does each type of reactor perform the key tasks of control of the rate of

reaction, moderation and cooling? What are the advantages and disadvantages of each type of reactor?
- the requirements for safe nuclear waste disposal and discuss whether Australia should have a nuclear waste dumping site.

research some of the ways in which radioisotopes can be used to diagnose medical conditions; investigation questions may include:

- what are the most common isotopes used to diagnose medical conditions?
- where and how are medical isotopes obtained?
- in what ways are medical isotopes used?
- what requirements are there on the lifetime and activity of medical isotopes?
- what are the requirements for a radioisotope used for medical treatment and how do these requirements differ from those used in medical diagnosis?
- what types of medical problems can be treated by the use of radioisotopes?
- in what ways can a sufficient radiation dose be delivered to cancer cells without endangering the patient?

in groups, calculate annual radiation doses at http://scilearn.sydney.au/fychemistry/calculations/radiation-dose.shtml

discuss whether golf clubs, tennis racquets and other personally selected sporting equipment should be standardised?

discuss how are ocean oil spills treated and determine whether the cleaning up of oil spills lead to a different set of problems for society?

discuss Herbert Spencer's quote that 'Science is organized knowledge' in terms of the value of placing elements into a periodic table

examine whether a product's life cycle be considered prior to the product being available to consumers? Is 'green chemistry' a social and political priority?

debate: 'would you drink recycled water?'

investigate issues relating to the desalination of sea water into fresh water.

research and explain how computer modelling of molecules can be used in medicinal drug design

compare the advantages and disadvantages of the use of fossil fuels and biofuels as energy sources.

look at group VII ions and their effect on the human body. Where are these ions most commonly found in natural foods?

examine incomplete combustion and risks to human health, explaining the requirements for safe use of kerosene and oil heaters (ie. well ventilated rooms)

Research

- heavy metal poisoning and explain why lead additives are no longer permitted in petrol
- diesel engines and soot particulates from incomplete combustion. Relate this to pollution levels in large cities and human health risks.

- the constitution of available fuel blends (for example, E10) for motorists and evaluate the advantages and disadvantages of using 100% petrol compared with a mixture of petrol and other fuels
- the chemistry of art: how are transition metals involved in the development of colour in art throughout history?

Investigate

- the chemistry of fireworks, examine how metals create colour.
- uses of diamonds, their mining and controlled release into the market place.
- the uses of flocculating agents in the mining industry: what are they, how do they work, what is the end result
- the role of chemistry in acid mine drainage in a Tasmanian context.
- radiometric dating techniques; compare methodoligies for dinosaurs fossils and ancient egyptian artefacts.
- the life cycle of a nuclear fuel examining the processes and stages for radioisotope decay.

Explore the production and use of allotropes of carbon such as graphene and nanotubes

The amount of acidic oxides have increased since the Industrial Revolution. Investigate the impact this is having on the environment

Explain the use of acids as food additives

Assess the use of neutralisation reactions as a safety measure or to minimise damage in accidents or chemical spills.

Detailed example

Would you drink recycled water?

The focus of this activity is on learners being able to consider the nature of evidence, distinguish between facts and opinion, and synthesise arguments to communicate a response to a chemistry-related social issue.

Aim

To communicate a justified response to a social issue involving chemistry concepts through participation in a 'Question & Answer' panel discussion.

Introduction

Teachers could organise the class so that learners work in groups to form a number of different Q&A panels where each learner takes on the role of a different stakeholder, or use a jigsaw approach to create one class Q&A panel with each panelist having a team of 'researchers' to assist in the development of panel arguments.

Learners role-play a Q&A panel discussion to examine the arguments for and against using recycled water as a source of drinking water. Each learner will assume the role of one stakeholder, or become part of the stakeholder's research team, and become part of the panel discussion. Following the panel discussion each learner provides an individual response to the question 'Would you drink recycled water?' by producing a public communication in an agreed format, for example newspaper article, infographic, or TV advertisement. The communication must include referenced qualitative and quantitative data, distinction between identified facts and opinions presented in the Q&A panel discussion and justified personal stance on the question.

Preparation

Prior learning experiences related to water sampling techniques, measurement of solubility and concentration, and analytical techniques used to analyse for salts, organic compounds, and acids and bases

Prior consideration of validity, facts and opinions, for example, learners discussed sources of reliable information related to the following chemistry-based information:

a) drinking water, also known as potable water or improved drinking water, is defined as water that is safe enough for drinking and food preparation

b) globally, in 2012, 89% of people had access to water suitable for drinking.

Learners should have discussed examples of 'effective' and 'ineffective' oral and written communication techniques and practices.

Learners become panel members that represent stakeholder interests (learners select the names of stakeholders at random 'from a hat'), for example local resident with young family, mayor, local water authority representative, analytical chemist, site worker from company contracted to carry out water treatment, medical professional, local producer of carbonated water, meteorologist, and environmental activist.

Learners should have access to 'fact sheets' or authoritative sites related to water treatment and drinking water specifications, for example excerpts from the Australian Drinking Water Guidelines at www.nhmrc.gov.au/guidelines-publications/eh52; World Health Organization's guidelines for drinking water quality at www.who.int/dwq/gdwq0506; comparison of drinking water standards around the world, such as found at www.safewater.org.

Health, safety and ethical notes

- learners should be respectful of others and their opinions at all times
- learners should be reminded that this activity is simply a role-play and the comments made do not necessary reflect the attitudes of the individual speakers.

Procedure

Learners should prepare by considering general information about the process of treating water to make it potable, including statutory requirements for water to be classified as 'drinkable'; put themselves in the role of one stakeholder and present their position; construct a question they would like addressed by a discussion panel; and plan possible responses to these questions from their perspective as one stakeholder. Some time out of class may also be required for learners to complete background research. Learners:

- read through the 'fact sheets' or websites relating to water treatment and water quality
- note the major points of interest
- select at random the name of a stakeholder relevant to the issue
- spend 10 minutes brainstorming the likely perspective of the stakeholder towards the issue. Learners may discuss their ideas with peers and the teacher. Learners need to consider the biases (feelings, opinions, prejudices) that their stakeholder may have for this issue and record these
- on a slip of paper, construct one question that they would like addressed by someone relating to this case study. Learners may suggest which stakeholder they would like to primarily respond to their question. The question should be well thought out so as to give as much insight into different perspectives in considering the issue

- submit the question to the teacher, who will collate (perhaps by photocopying all slips onto a single sheet of paper) and distribute them to the relevant discussion panel
- now working with the other members of the panel, discuss the questions that have been submitted and write notes detailing the response to these questions from the perspective of a stakeholder. Include as much scientific data as possible in the responses. Learners may need to conduct additional Internet research to develop responses.

Evidence of learning

Learners provide an individual response to the question 'Would you drink recycled water?' by producing a public communication in an agreed format, for example newspaper article, infographic or TV advertisement. By the end of the lesson they submit a draft of their response. They may use any notes they have.

The communication must include referenced qualitative and quantitative data, distinction between identified facts and opinions presented in the Q&A panel discussion and justified personal stance on the question.

The media communication should identify / highlight the:

- likely target audience
- specific scientific concept/s being communicated
- distinction between fact and opinion
- scientific data used to justify position of the stakeholder.

Apply concepts and processes of atoms and nuclear reactions

Criterion 4 ***Examples of learning activities***

Learners:

interpret mass spectra to determine relative atomic masses

perform calculations of relative atomic masses from abundances and relative isotopic masses

play with the periodic table: https://ptable.com/#Writeup/Wikipedia or http://www.chemicalelements.com/

use simulations to investigate atomic structure, for example Build an Atom; Isotopes and Atomic Mass; Models of the Hydrogen Atom https://phet.colorado.edu/en/simulation/build-an-atom

view emission spectra of various elements; perform flame tests by heating various metallic compounds in a flame; use a spectrometer to observe and compare the emission spectra obtained from the flames; use these findings to suggest how the different colours in fireworks may be generated

investigate penetrating power over distances and absorption of radiation by various barriers and thicknesses

simulate how unstable (radioactive) elements change into more stable nuclei; explore the concept of half-life using a container of M&Ms®, Skittles® or two-sided discs with different colours on each side; perform a series of 'spills' and 'removals' to model nuclear decay use a radiation counter to record the decay of the short-lived protactinium source and determine its half-life

compare the intensity of background radiation in a variety of places: inside and outside a building, in well and in poorly ventilated areas, at ground level and the top floor of a multi-level building, and inside wood-, concrete- and plaster-walled rooms

undertake practical investigations and simulations related to atoms and nuclei such as those at www.nuffieldfoundation.org/practical-physics/atoms-and-nuclei

use simulations to explore alpha and beta decay, for example https://phet.colorado.edu/en/simulation/beta-decay and https://phet.colorado.edu/en/simulation/alpha-decay

explore fission using applets such as those found at https://phet.colorado.edu/en/simulation/nuclear-fission

Investigate why is energy released in both fission and fusion reactions? What are the end products in each case?

describe how a fission reactor is controlled and how the energy output is managed

explore the effect on the environment of nuclear accidents by accessing sites such as www.angelfire.com/extreme4/kidofspeed/chapter1.html, which provides an account of the impact of a nuclear accident on the environment, in this case Chernobyl (1986), long after the accident took place (links with Criterion 3)

explore nuclear chemistry: www.nclark.net/NuclearChem

visit the radiology department of a local hospital; construct a one-page infographic that summarises the types of diagnostic and treatment options offered by the department, including the medical purposes for each option offered (links with Criterion 3)

determine the effective dose that a 25-year-old person may expect to have been exposed to in an average life

use a radiation monitor to observe the activity of a variety of sources; explain how a smoke detector works and the arrangements that should be made for its disposal

explain how radioisotopes are routinely used to diagnose medical conditions of patients, how this is achieved - identifying the limitations of this technology for diagnostic purposes

use video to start a discussion for example: veritasium https://www.youtube.com/watch?v=wQmnztyXwVA or Hewitt Drewit https://www.youtube.com/watch?v=MtaJLRLIKO4

Detailed example

Simulating radioactive decay and half-lives

Background

A radioactive element will have some nuclei that are stable and other nuclei that are unstable. The stable nuclei don't change but the unstable nuclei transmute or 'decay' into more stable nuclei and emit radioactivity. The half-life is the time taken for half the radioactive nuclei to decay. Half-lives vary for different elements; for example, lithium-8 has a half-life of 0.85 seconds while uranium-238 has a half-life of 4.51 billion years.

Aim

To simulate how unstable (radioactive) elements change into more stable nuclei and to explore the concept of half-life.

Materials (for each group of learners)

- between 60 and 130 M&Ms®, Skittles® or two-sided discs with different colours on each side into a container to represent unstable nuclei
- 1 plastic or paper cup
- 2 sheets of paper towelling
- graph paper or a spreadsheet

Method

1. place between 60 and 130 M&Ms®, Skittles® or two-sided discs with different colours on each side into a plastic or paper cup to represent unstable nuclei.
2. carefully spill the 'nuclei' onto a paper towel sheet. The spill represents a half-life of a radioactive element.
3. spread the nuclei out on the paper towel to identify whether the manufacture's label, or a selected disc colour, is facing 'up' or 'down'.
4. the 'up' facing nuclei represents decayed nuclei, and should be counted, recorded in a table such as the one below, removed and placed onto a second paper towel sheet.
5. the remaining nuclei are replaced in the plastic or paper cup, and spilled again to represent the second half-life. Decayed nuclei should be counted, recorded and removed.
6. step 5 should be repeated until all nuclei have decayed.

Results

Learners should record their results using a table based on the following:

Spill (half-life)	Expected number of nuclei remaining based on previous sample size	Actual number of nuclei remaining after spill	% decayed nuclei
0	(starting number of nuclei)	-	-
1			
2			
3			
4			
5			
6			

Learners should graph their results by plotting the spill (half-life) on the x-axis and the number of remaining nuclei on the y-axis.

Discussion

Class results should be collated and learners could respond to a series of graded questions, for example:

- what are the strengths and weaknesses of this activity as a simulation of radioactive decay?
- how do your experimental results compare with predicted results?
- is there an advantage to collating class results?
- how does collating class results relate to radioactive nuclei?
- can half-life predict the actual length of time it takes for a particular nucleus to decay?
- how is the graph of your results similar to, and different from, the graphs of other learners? How is the graph of your results similar to, and different from, the graph of collated class results?
- does half-life depend on the initial mass of the sample?
- if you could track a particular nucleus in a radioactive sample, could you predict when it would decay?

Extension

This activity can be extended using a die. Calculations of theoretical half-lives in each case is more complicated than using M&Ms®, Skittles® or two-sided discs with different colours on each side, and will require application of probabilities.

- learners roll a die where rolling a 1 corresponds to decaying, and record results.
- learners roll a die where rolling a 1 or 2 corresponds to decaying, and record results.
- learners compare results and comment on predictability of radioactive decay of nuclei.

Apply concepts and processes of motion and force

Criterion 5 ***Examples of learning activities***

Learners:

describe the motion of an object based on a velocity-time graph

use dataloggers and/or digital video cameras to investigate the displacement, velocity and acceleration of learners as they perform long jumps and high jumps

throw a ball and calculate the initial velocity and maximum height by measuring the range and time of flight

record and analyse motion using computer software, for example 'Tracker' or 'Pasco'

projectile motion investigations:

- with (Nerf) ball launchers, a hose or bow and arrows to determine all calculations associated with projectile motion
- ball and ramp
- monkey and the hunter

examine the forces on a person sitting in a plane at constant velocity and compare to the forces on the plane itself

use phet.colorado.edu activities to investigate motion, e.g: https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html

consider misconceptions about falling, for example www.youtube.com/watch?v=_mCC-68LyZM

use bathroom scales or force platform (eg. Pasco) to measure reaction forces when sitting, leaning against a wall and walking on the scales – model N3L by pressing scales together – see who can push harder

use bathroom scales, force platform (eg. Pasco), accelerometer or 'Science Journal' app to observe the change in reaction force when riding a lift in a tall building

measure the acceleration of trolleys of different masses under the influence of a range of known forces

develop a spreadsheet that models the motion of a sky diver approaching terminal velocity

complete a practical activity (e.g. drop a ball, 'Technique' aka 'Hudl' app) and discuss the reasons that a falling object usually does not accelerate at the expected rate of 9.81 m s-2

design and present a demonstration of Newton's laws

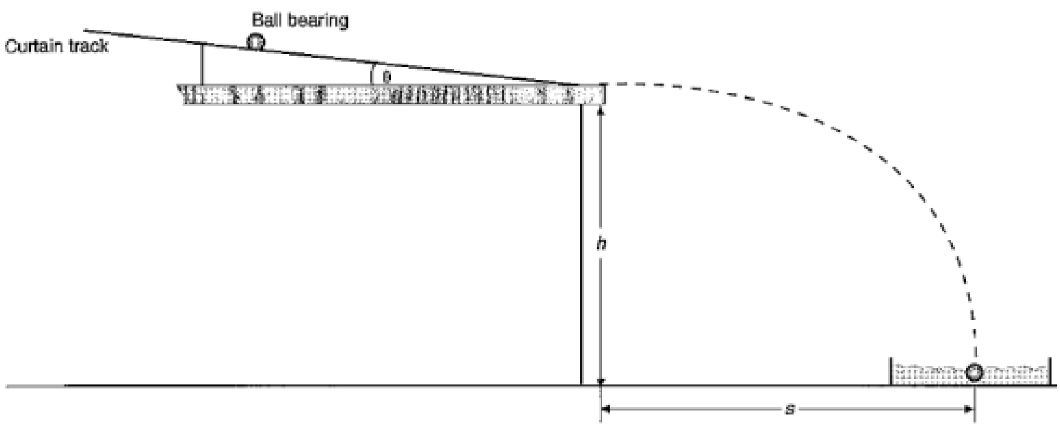
discuss the various forces operating on an aircraft in flight and the effect of each of them

observe and describe a bullet being fired and a bullet being dropped hit the ground at the same time: https://www.youtube.com/watch?v=tF_zv3TCT1U

observe and describe the effects of air resistance (dropping a feather and a bowling ball in a vacuum): https://www.youtube.com/watch?v=E43-CfukEgs

Detailed example

Investigating projectile motion



Introduction

When the ball bearing is released, the distance, s, that it lands from the foot of the bench is said to depend on its velocity, v, when leaving the table and the height, h, that it is above the floor.

Method

Learners:

- set up the apparatus as shown in the diagram.
- release the ball bearing and adjust the position of the sand tray such that it catches it.
- measure the distance, s, and height, h
- Investigate the effect of height h on the range s.

Learners should predict, plan for and investigate:

- where will errors occur? What is the most appropriate method of dealing with them?
- what factors do you need to keep constant during this investigation?
- what measurements will be taken? Will they be suitable for plotting a graph?
- how will errors be estimated? How will errors in any derived value be estimated?
- how the theory may be related your results to the predicted ones and any assumptions that the theory makes.

The report for the investigation should clearly articulate:

Aim and method

- the hypothesis and reasons for this hypothesis
- the independent variable and how it is measured
- the dependent variable and how it is measured
- the variables that need to remain constant and how you know that they will remain constant
- a sketch of your experimental set-up
- any special measuring techniques that would make your results more reliable

Results

- the data collected presented in an organised manner
- where appropriate graph(s) plotted in such a way as to allow gradient(s) to be calculated if appropriate and intercept(s) found

Discussion

- a description of the data including any trends
- all calculations made clearly shown

Conclusion

- a conclusion or conclusions drawn from the available evidence
- an estimate of the errors involved and a comment as to the reliability of the final conclusion

Apply concepts and processes of conservation in physics

Criterion 6 ***Examples of learning activities***

Learners:

compare the explanation of motion offered by Aristotle and Newton for a ball rolling downhill

explore applets that visually show energy transfer, for example, Skate Park in Phet, found at https://phet.colorado.edu/

investigate the conservation of momentum, for example comparing total momentum before and after various types of collisions between carts or air track gliders (Video Physics iPad app, or Photogates w/ air-tracks)

apply concepts of momentum and energy to explain how Newton's Cradle works; construct a Newton's Cradle from scratch as demonstrated at www.youtube.com/watch?v=fyACAc1eJu8, evaluate its efficiency and suggest improvements that could be made

use self-designed crumple zones attached to motion trolleys to investigate inelastic collisions (the speed of the motion trolleys can be measured using ticker timers or dataloggers)

explore energy conservation using a toy rollercoaster, including impact of friction.

measure power outputs as each class member runs up a flight of stairs

observe and explain the Mythbusters cancelling out velocity/momentum: https://www.youtube.com/watch?v=BLuI118nhzc

show surplus and deficiency of electrons using static electricity experiments: e.g. van de graaf generator; separating salt & pepper; bending water (link with polarity [C7]); electroscope; picking up paper with a friction charged pen/comb; blow bubbles at van der Graph generator.

experiment with a bulb, a battery and one lead and suggest how the bulb can be made to light up

Investigation of ohmic (resistors) vs. non-ohmic resistance (different types of bulbs inc. diodes)

set experiments for investigating variation of current with applied voltage for non-ohmic devices

investigate whether two 60 W light bulbs shine brighter than three 40 W light bulbs

experiment with a set of batteries and light bulbs in various series and parallel combinations and explain the observations; add ammeters and voltmeters to the batteries and light bulb circuits to measure the currents, voltages and resistances of the bulbs

compare and evaluate analogies used to explain current and potential difference (e.g. water; learners as charge carriers passing an object [lollies] which represents energy, including chairs as resistors; rope)

construct a table of typical power usage of domestic appliances and investigate domestic electrical safety provisions

energy transformation: efficiency of a small electric motor

analyse an energy bill

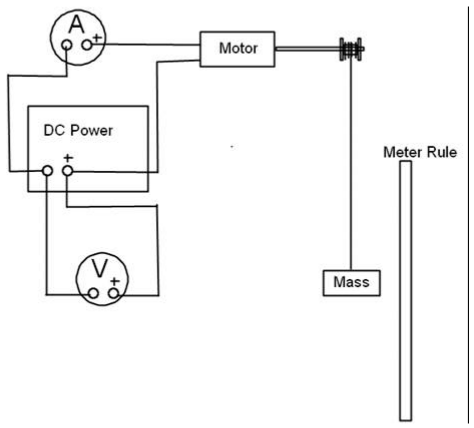
Detailed example

The efficiency of a small electric motor

Learners measure the power input and output and calculate the efficiency of a small electric motor.

Learners:

- clamp a small electric motor to a retort stand so that its pulley is about 1.5m above the floor.



- attach a 100g mass to the pulley using strong thread. Ensure that the thread winds around the pulley several times while the mass is on the floor. Clamp a metre rule to the bench or the retort stand near the thread about 25cm above the floor.
- connect a DC power supply to the motor along with a voltmeter and an ammeter.
- turn on the power and adjust the voltage so that the mass is lifted past the ruler at a constant speed.
- must ensure to turn off the power before the mass hits the pulley and then catch the mass.

Results

Once the mass is rising at a steady rate, the system is ready to be measured recording your results in a table such as:

	Trial 1	Trial 2	Trial 3	Average
Time (s)				

Current (A)				
Voltage (V)				

When the mass is rising,

- measure the time for it to rise 1.0 m and
- record the current through and the voltage across the motor.

Do this 3 times and average the results.

Discussion and conclusion

When learners have completed the experiment they can dicuss their findings ensuring they calculate and comment on the:

- work done by the motor on the mass in lifting it one metre.
- useful power output from the motor.
- electrical power input to the motor.
- values above to calculate the % efficiency of your motor.

Learners need to describe and explain:

- where has the lost energy gone?
- difficulties with the procedure, sources of error and further lines of investigation they may pursue.

Apply concepts and processes of chemical structures and properties

Criterion 7 ***Examples of learning activities***

Learners:

compare the chemical properties of main group metals, for example, reaction with water and reaction with acid (where safe), including testing for products and formation of colourless and coloured compounds

create models of, and name, hydrocarbons (alkanes, alkenes, alkynes and haloalkanes), including structural isomers

prepare a summary sheet or flow chart outlining the rules for naming organic compounds

investigate some allotropes of carbon by viewing computer-generated models of models of diamond, graphite, a 'buckyball' and a carbon nanotube; compare similarities and differences between their structures; explain their properties in terms of their structures

demonstrate the polarity of water by bringing a charged rod slowly towards a stream of water from a tap; draw labelled diagrams that explain the resultant distortion of the water stream

compare the degree of solubility of a range of ionic salts and molecular substances in water.

growing ionic crystals on a slide and viewing them with a microscope

use solubility rules to predict the outcomes of precipitation reactions and experimentally test the predictions; write 'full' and ionic equations for precipitation reactions that occur

use data from a number of analytical techniques to determine the identity of a compound

design a procedure to identify an unknown salt dissolved in a water sample

conduct flame tests

confirm the Law of Conservation of Mass for a chemical reaction in a closed system; model the chemical reaction to show the rearrangement of atoms

explain why holding an inverted white evaporating dish above a yellow Bunsen burner flame produces black soot under the dish

bromine test for unsaturation

tour an analytical laboratory to observe chemical instrumentation at work; process sample data

observe a demonstration of combustion and explain the process and products: "Products of Combustion" - candle under a bell jar, gas through a cooled u bend – water condenses, and gas will discolour lime water

perform precipitation reactions: grid of sample anions and cations and predict and compare the precipitate formation with what is theoretically predicted.

Detailed example

Analysis for chemical structure

As there are an infinite number of different substances scientists look for similarities and differences in properties to develop models and theories about the possible underlying structure of a substance.

In this activity learners will investigate some of the physical properties of metals, ionic, covalent molecular and covalent network substances.

Around the room are various workstations.

Learners will visit each work station around the room and investigate the properties of the substances and fill in the data tables

A multimeter can be used to find out whether a particular substance is a conductor or not. The meter should be on the resistance setting and on the 1000 W (ohm) scale. Between each test either clean or change the probes to prevent contamination

Equipment required

STATION A	STATION C
Metallic	*Covalent Molecular*
Tin (Sn) Copper (Cu)	Nitrogen gas, Carbon dioxide

Lead(Pb) Use gloves
Mercury (Hg)
Hammer
Multimeter

Paraffin Wax
Sulfur
Sugar
Oil

STATION B

Ionic

Sodium chloride
Potassium nitrate
Copper sulfate
Hammer, multimeter, beakers, spatula

TEACHER DEMO: $LiCl_{(s)}$

STATION D

Covalent Network

Silicon dioxide-Quartz
Silicon dioxide sand
Graphite
Diamond

Learners should record their results in tables such as:

Station A: Metallic elements

No	Material	Formula	Appearance at room temp	Malleability (outcome when hammered)	Solubility in Water	Conductivity at room temp.	Density, relative to water.
1	tin						
2	copper						
3	lead						
4	mercury						

Station B: Ionic compounds

No	Material	Formula	Appearance at room temp	Malleability (outcome when hammered)	Solubility in Water	Conductivity at room temp.	Density, relative to water.
1	sodium chloride						
2	potassium nitrate						
3	copper sulfate						

Station C: Covalent molecular

No	Material	Formula	Appearance at room temp	Malleability (outcome when hammered)	Solubility in Water	Conductivity at room temp.	Density, relative to water.
1	nitrogen gas						
2	paraffin wax	$C_{22}H_{46}$					
3	sulfur						
4	sugar						
5	oil						

Station D: Covalent network

No	Material	Formula	Appearance at room temp	Malleability (outcome when hammered)	Solubility in Water	Conductivity at room temp.	Density, relative to water.
1	silicon dioxide (quartz)						
2	silicon dioxide (sand)						
3	graphite						
4	diamond						

Discussion and conclusion

When analysing their results learners should comment on the general patterns in their data and relate them to the attributes of the four bonding types. Learners should reflect on the utility and the limitations of this model of bonding in light of their results and be explain where the models agree and deviate from their observations.

Apply concepts and processes of chemical reactions and reacting quantities

Criterion 8 ***Examples of learning activities***

Learners:

visualise the mole by calculating how deep a 'blanket' of a mole of marshmallows over Australia would be, or how high a 'tower' made from a mole of dollar coins or sheets of A4 paper would reach, or how long it would take to count a mole of marbles if you counted one every second every day until finished

use an 'if…then…when…' structure to develop hypotheses related to empirical formulae determinations and test the predictions inherent in these hypotheses

solve quantitative exercises involving the mole and Avogadro's constant

solve quantitative mass to mass exercises involving balanced equations and the mole concept

practically demonstrate the empirical formula of magnesium oxide solve quantitative exercises involving empirical and molecular formulas of organic compounds

solve quantitative exercises involving ionic compounds and water of crystallisation

calculate, using practically determined masses, the water of crystallisation of copper sulfate through dehydrating a hydrated sample

relate the strength and concentration of acids and bases to the safety procedures for their use

discuss the accuracy, precision and validity of collated class measurements of the pH of a variety of everyday solutions, for example tap water, bottled mineral water, distilled water, saline solution, drain cleaner (sodium hydroxide), vinegar (acetic acid), dishwashing powder (sodium carbonate), cloudy ammonia, baking soda, battery acid (sulfuric acid), concrete cleaner (hydrochloric acid), albumin and yolk of an egg

examine the ingredients list of chemicals and foods for which solution quantities are provided; convert between given units and alternate units of concentration, for example g L-1, mg L-1, %(m/m), %(m/v), %(v/v)

perform dilutions of different solutions and calculate quantities at each dilution stage

relate to pH by doing a dilution series for an acid with indicator (can do in parallel with a dye)

discuss principles and applications of gravimetric analysis

perform a gravimetric analysis and use mass-mass stoichiometry to determine the mass of salt in a water sample; collate and compare class data to evaluate accuracy and precision; discuss whether performing repeated analyses improves accuracy and precision

perform an acid-base titration and use volume-volume stoichiometry to calculate the concentration of an acid or base in a water sample

discuss criteria for selection of primary standards (for titration?)

prepare a standard solution and use this to find the concentration of an acid or base of unknown concentration

distinguish between the equivalence and end point of a reaction; evaluate the strengths and limitations of volumetric analysis

discuss the pH changes that occur during the titration by analysing the curve of a titration plot

carry out volumetric analysis (direct titration) of acid/base content of consumer products, for example acid content of vinegar, white wine or fruit juices; carbon dioxide content of fizzy drinks; carbonate content of health salts

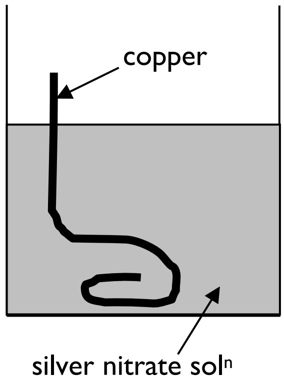
solve quantitative exercises involving acid-base reactions; use volume, concentration and mass of reactants

Detailed example

Reacting quantities practical: silver nitrate and copper

Learners will investigate the mole quantities involved in the reaction between an aqueous solution of silver nitrate ($AgNO_{3(aq)}$) and copper metal ($Cu_{(s)}$).

Learners will:



- obtain a piece of 16 gauge copper wire of length approximately 12 cm. Clean it using steel wool to ensure that its surface is completely free of any oxide layer or other compounds
- using a pencil or similar, wind the copper wire into a coil but leave a short section that is straight. This will act as a handle. (See diagram)
- find the mass of the copper wire to the nearest 0.01 g
- obtain a clean dry 100 mL beaker and using the 'tare' facility on the electronic balance, weigh out into the beaker a known mass of pure, dry silver nitrate crystals (AgNO3)

  (the mass should be in the range 1.80 – 2.20 g and recorded in a table of results

  CARE: Avoid contact of AgNO3 with the skin as staining may occur)
- add approximately 50 mL of distilled water to the AgNO3 crystals and dissolve them by using a stirring rod. (When the dissolving is complete, rinse the stirring rod with a little distilled water from a wash bottle so as not to lose any AgNO3 solution.)
- place the weighed copper coil in the silver nitrate solution and observe it for several minute and record their observations
- cover the beaker with a watch glass and label it with your group's initials. Leave the system for at least 24 hours to guarantee a complete reaction
- using a spatula, carefully scrape all the silver metal off the copper coil back into the beaker. Then wash the copper coil with water and dry it with paper towel
- weigh the remaining copper coil and record its 'final' mass in the table of results.
- decant the supernatant liquid from the beaker and wash the silver metal several times with distilled water from a wash bottle
- finally wash the silver metal with methylated spirits and allow the silver metal to dry on a labelled watch glass in an oven or in front of a fan heater
- find the mass of dry silver metal that has been displaced by the copper metal and record this value

Results

Mass of silver nitrate ($AgNO_3$) crystals used	
Mass of copper metal (Cu) coil initially	
Mass of copper metal (Cu) coil finally	
Mass of copper metal (Cu) coil reacted	
Mass of silver metal (Ag) displaced finally	

Discussion and conclusion

Within their discussion and conclusion learners should calculate and comment on the:

- number of mole of $AgNO_3$ reacted; i.e. $n(AgNO_3)$ from the mass of silver nitrate crystals used and the molar mass of $AgNO_3$
- change in mass of the copper coil and hence calculate the number of mole of copper reacted; i.e. n(Cu)
- number of mole of silver metal produced in the reaction; i.e. n(Ag) from the mass of silver metal obtained
- value of the two ratios using the mole data above:

$$\text{Ratio 1} = \frac{\text{n(Ag) produced}}{\text{n(Cu) reacted}} \quad \text{Ratio 2} = \frac{\text{n(AgNO}_3\text{) reacted}}{\text{n(Ag) produced}}$$

- the AVERAGE value of the RATIOS 1 and 2 using all the results from the class
- theoretical values for each ratio indicated above using the balanced chemical equation below

i.e. $2\ AgNO_{3(aq)} + Cu_{(s)} \rightarrow Cu(NO_3)_{2(aq)} + 2\ Ag_{(s)}$

- % error for the class average values:

% ERROR MOLE RATIO 1 and % ERROR MOLE RATIO 2:

Further learners need to comment on and explain the:

- sources of error they encountered in this experiment
- assumptions that we have made in performing this experiment
- improvements that can be made to alleviate the effects of these sources of error and would increase the accuracy of this experiment.