# Internal School Curriculum

For Grades 9 and 10 in Subject

# Physical Science

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# Introduction

Concepts for acquisition of skills

Educational value of Physics

Learning from Physics
Learners are taught to orientate in their environment and to develop criteria for their future actions by detecting the key concepts and ideas in Physics classes, thereby investigating how to shape their own world of experiences. In Physics lessons they clearly experience the connection between experiment/theory (model) and real life. In this way, Physics helps them to understand their environment better and it serves as a guideline for shaping their futures.

In addition to getting acquainted with facts about the origin and interactions of all aspects of our world, which is of central importance for their identity formation, learners are taught the principles of Physics, which accommodate man-made models in their environment. This does not only apply to Physics lessons which seem rather theoretical, but especially for the everyday world of learners.

In this way learners can read and understand their immediate and distant environment with an increasingly sharpened scientific eye.

The current Physics curriculum is focused on areas of classical Physics like mechanics, optics, and thermodynamics but in addition also on modern theories which developed in the last century, mainly reflected in nuclear Physics.

The current curriculum is based on the 2016 Baden-Württemberg training-specifications. The explanatory skills, specified therein, form the basic structure of the curriculum. These content-related competencies are arranged by basic (B), intermediate (I) and advanced level (A).

Remarks for Grades and course levels:

In the junior secondary grades (Grades 7 to 9), the subject is taught in German in two periods per week. This is reflected in the total scheduled lesson on the relevant topics.
In Grades 10 to 12 bilingual lessons are offered. By teaching Physics terms in English and German, apart from purely technical skills acquisition, a high level of linguistic skills are acquired and expected from the learners.

# Procedure-related skills

## 1. Gaining knowledge

Learners observe and describe phenomena and derive questions which they can examine physically. They apply scientific working procedures, i.e. they apply experiments to test hypotheses, conduct experiments, analyze them and document the results. In their descriptions they differentiate between real experiences and contrived models, identify correlations and use models to explain physical phenomena.

Learners are able to

**conduct targeted experiments**

1. target-oriented observation of phenomena and description of their observations;
2. set up hypotheses on physical questions;
3. design experiments to test hypotheses (i.e. adjust presumed influencing values separately);
4. perform and evaluate experiments;
5. capture readings and perform computer analysis;
6. use digital data measurement systems; (A)

**modeling and mathematization**

7. produce simple mathematical correlations between physical quantities and verify (in particular proportionality of two quantities);
8. develop equations of proportional correlations; (A)
9. perform mathematical transformations to calculate physical quantities; (A)
10. differentiate between real experience and contrived, idealized model concepts (i.e. the differentiate between observations and explanations);
11. describe correlations and use to solve problems;
12. explain phenomena and formulate hypotheses by means of models;

**acquire and apply knowledge**

13. apply their knowledge of Physics to solve problems and tasks purposefully;
14. gain and apply knowledge beyond school.

## Communication:

Learners discuss physical findings and the application thereof by using subject-related terminology and representations. They distinguish between every-day and technical language descriptions. They increasingly describe physical situations by using mathematical forms of representations. They select information from various sources to solve problems. They discuss issues under physical aspects and document their results and present them suitably for their target group.

Learners are able to

**verbalize findings**

1. distinguish between every-day and technical language descriptions;
2. verbally describe functional correlations between physical quantities (e.g. 'the - the' expressions) and explain physical formulas (e.g. cause-effect statements, unknown formulas);
3. exchange information on physical findings and on their application by using subject related language and representations (e.g. distinction between variable and unit, use of pre-fixes);
4. describe physical processes and technical devices (e.g. time sequences, cause-and effect correlations);

**document and present findings**

5. document physical experiments, results and findings - also by using digital media (e.g. drawings, descriptions, tables, diagrams and formulas);
6. conclude factual information and measurement data from one representation format and transfer it to another (e.g. table, diagram, text, formula);
7. obtain information from different sources, structure knowledge clearly, process in a relevant and target-group-oriented way and present by using appropriate media.

## Assessment

By using examples, learners assess possibilities and limitations of physical perspectives in purely physical and non-subject-related contexts. They compare and assess alternative scientific solutions. They use their physical knowledge to assess the risks and security measures of experiments of everyday activities and in modern technologies. They designate effects of physical findings in historical and social contexts. Learners evaluate information and scrutinize its relevance.

Learners are able to

**reflect physical procedures**

1. distinguish relevant from irrelevant variables in experiments
2. rate results of experiments (measurement errors, accuracy);
3. asses hypotheses according to results of experiments;
4. use examples to explain limitations of physical models
5. evaluate climate change scenarios; (E)

**rate information**

6. examine information from various sources for relevance;
7. critically observe media presentations based on their physical findings (e.g. films, newspaper articles, pseudo-scientific statements);

**discuss opportunities and risks**

8. evaluate risks and safety measures in experiments and in everyday life, based on their physical knowledge;
9. assess opportunities and risks of technologies by applying physical knowledge;
10. discuss technologies, by taking social, ecological and economical aspects into consideration;
11. differentiate between local and global action in sustainable development by means of their physical knowledge;
12. describe historical effects of physical findings;
13. discuss gender clichés regarding interests and career choices in the scientific-technical field.

# Physics-oriented thinking and working methods for Grades 9 and 10

| B | I | A |
|---|---|---|
| 1) Name criteria for distinguishing between observation and explanation (observation by perception and measurements, explanation by laws and models) | (1) Describe criteria for distinguishing between observation and explanation (observation by perception and measurements, explanation by laws and models) | (1) Describe criteria for distinguishing between observation and explanation (observation by perception and measurements, explanation by laws and models) |
| (2) By means of examples describe, that statements in Physics are generally verifiable (question, hypothesis, experiment, proof or disproof) | (2) By means of examples describe, that statements in Physics are generally verifiable (question, hypothesis, experiment, proof or disproof) | (2) By means of examples describe, that statements in Physics are generally verifiable (question, hypotheses, experiment, proof or disproof) |
| (3) Describe the function of models in Physics (i.e. by means of the *light beam model* and the *particle model)* | (3) Describe the function of models in Physics (i.e. by means of the *light beam model* and the *particle model)* | (3) Explain the function of models in Physics (i.e. by means of the *light beam model* and the *particle model)* |
| | | (4) Describe the significance of the *SI-unit system* by means of examples. |

# Grade 9

| 9. | Electromagnetism | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Content-related skills**<br>**B** | **I** | **A** | **Contents (compulsory for the region)** | **Time in lessons** | **Methods curriculum** | **School-specific supplements and additions** |
| | (1) examine and describe the magnetic effect on a current-carrying *coil* | (1) examine and describe the magnetic effect on a current-carrying *coil* | (1) examine and describe the magnetic effect of a current-carrying straight *conductor* and a current-carrying *coil*. | Revision of Grade 7 topics (field, poles, effects)<br>Magnetic field around conductors and coils | 4 | Group puzzle, learners plan and perform experiments independently | |
| | (2) examine and describe *electromagnetic induction* qualitatively<br><br>(3) describe simple application of electromagnetism functionally (e.g. electromagnet, electric motor)<br><br>(4) explain the *functioning of a generator* and transformer by means of *electromagnetic induction* | (2) examine and describe *electromagnetic induction* qualitatively<br><br>(3) describe simple application of electromagnetism functionally (e.g. electromagnet, loudspeaker, electric motor)<br><br>(4) explain the *functioning of a generator* and transformer by means of *electromagnetic induction* | (2) examine and describe *electromagnetic induction* qualitatively<br><br>(3) describe simple application of electromagnetism functionally (e.g. electromagnet, loudspeaker, electric motor)<br><br>(4) explain the *functioning of a generator and a transformer* by means of *electromagnetic induction* | Lorentz force and induction (qualitative)<br>• Right- and left-hand-rule<br>• Experiment conductor swing<br>• Applications in a motor<br>• Generator<br>• Transformer | 12 | Learner experiments | *Induction torch* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | .<br>. | . | . | | | | |
| | (5) describe basic characteristics of *direct- and alternating current*<br><br>(6) describe Physical aspects of everyday devices (battery, direct voltage, alternating voltage) | (5) describe basic characteristics of *direct- and alternating current*<br><br>(6) describe Physical aspects of everyday devices (battery, direct voltage, alternating voltage) | (5) describe basic characteristics of *direct- and alternating current*<br><br>(6) describe Physical aspects of everyday devices (battery, direct voltage, alternating voltage) | Electricity- and energy supply<br>• High-voltage power lines<br>• Risks and benefits in everyday life | 4 | Learner presentations | |
| **9.2** | **Atomic and Nuclear Physics; structure of matter** | | | | | | |
| | **Content-related skills**<br><br>**B** | **I** | **A** | **Contents (compulsory for the region)** | **Time in lessons** | **Methods curriculum** | **School-specific supplements and additions** |
| | (1) briefly describe the structure of matter and explain the structure of the atomic nucleus (*atom, atomic shell, nucleus, proton, neutron,* atomic number, nuclear number, *isotopes*) | (1) briefly describe the structure of matter and explain the structure of the atomic nucleus (*atom, atomic shell, nucleus, proton, neutron,* atomic number, nuclear number, *isotopes*) | (1) briefly describe the structure of matter and explain the structure of the atomic nucleus (*atom, atomic shell, nucleus, proton, neutron,* quarks, atomic number, nuclear number, *isotopes*) | Nuclear structure and isotopes | 4 | Work with models | *Optional: Atomic models*<br>• *Leukipp/ De Mokrit*<br>• *Dalton*<br>• *Thomson*<br>• *Rutherford*<br>• *Bohr* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (2) describe *nuclear disintegration* and ionizing radiation (*radio activity, α-, β-, γ- radiation*) | (2) describe *nuclear disintegration* and ionizing radiation (*radio activity, α-, β-, γ- radiation*) | (2) describe *nuclear disintegration* and ionizing radiation (*radio activity, α-, β-, γ- radiation*) | Radio activity<br>• Alpha-, Beta and Gamma- radiation<br>• Effects and properties of these types of radiation<br>• Dangers of radiation | 8 | Jigsaw-method | *Natural Uranium deposits, biological radiation exposure* |
| | (3) describe *nuclear fission* | (3) describe *nuclear fission* | (3) describe *nuclear fission* | Nuclear fission and fusion | 6 | | |
| | (4) describe biological effects and health consequences of ionizing radiation as well as significant medical and technical applications<br><br>(5) evaluate risks and benefits of medical and technological applications of ionizing radiation and *nuclear fission* | (4) describe biological effects and health consequences of ionizing radiation and name medical and technical applications.<br><br>(5) describe and evaluate risks and benefits of medical and technological applications of ionizing radiation and *nuclear fission* | (4) describe biological effects and health consequences of *ionizing radiation* and name medical and technical applications.<br><br>(5) describe and evaluate risks and benefits of medical and technological applications of ionizing radiation and *nuclear fission*<br><br>(6) describe a medical application physically | Benefits and risks of nuclear energy<br>• Nuclear power plants<br>• Medical applications (diagnosis and treatment)<br>• Nuclear bombs and nuclear incidents | 10 | Learner presentations | *Uranium deposits in Namibia, economic aspects* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (7) name risks for human health and safety measures (e.g. shielding of ionizing radiation, radioactive waste disposal) | (7) name risks for human health and safety measures (e.g. shielding of ionizing radiation, radioactive waste disposal) | (e.g. Spirometer, ECG (electrocardiogram), X-ray imaging, tumor radiation)<br><br>(7) describe risks for human health and safety measures (e.g. residual current circuit breaker, shielding of ionizing radiation, radioactive waste disposal) | | | | |
| | (8) compare different kinds of power supply under physical, ecological, economic and social aspects (e.g. fossil fuels, nuclear energy, wind energy, solar energy) | (8) compare different kinds of power supply under physical, ecological, economic and social aspects (e.g. fossil fuels, nuclear energy, wind energy, solar energy) | (8) compare and evaluate different kinds of power supply under physical, ecological, economic and social aspects (e.g. fossil fuels, nuclear energy, wind energy, solar energy) | Compare nuclear energy, fossil energy supply and renewable energy supply | 6 | | |

| **9.3** | **Solid State Physics** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Content-related skills**<br><br>**B** | **I** | **A** | **Contents (compulsory for the region)** | **Time in lessons** | **Methods curriculum** | **School-specific supplements and additions** |
| | (1) examine and describe simple electronic components functionally and explain their application (e.g. diode, LED, temperature- or light dependent resistors) | (1) examine and describe simple electronic components functionally and explain their application (e.g. diode, LED, temperature- or light dependent resistors) | (1) examine simple electronic components, functionally describe them according to their *characteristics* and explain their application (e.g. diode, LED, temperature- or light dependent resistors) | Diodes and transistors, applications in rectifiers, switches and amplifiers<br><br>Photo voltaic cell | 6 | Work with models | *Optional: Conduction processes in metals, fluids, gases and semi-conductors* |

# Grade 10

| 10.1 | Kinematics | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Content-related skills**<br>**B** | **I** | **A** | **Contents (compulsory for the region)** | **Time in less** | **Methods curriculum** | **School-specific supplements and additions** |
| | (1) determine *speeds* experimentally and create motion charts (*s-t graph,* $v = \frac{s}{t}$)<br><br>(2) derive rules for safe behavior in traffic from their knowledge on mechanics (e.g.: reaction time) | (1) determine *speeds* experimentally and create motion charts<br>(*s-t graph,* $v = \frac{s}{t}$)<br><br>(2) derive rules for safe behavior in traffic from their knowledge on mechanics (e.g.: reaction time) | (1) determine *speeds* experimentally, record movements (e.g. by means of data acquisition or video analysis system) and create corresponding *movement charts* (*s-t graph, v-t graph)*<br><br>(2) derive rules for safe behavior in traffic from their knowledge on mechanics (e.g.: reaction time)<br><br>(3) illustrate and apply quotient formation of *distance* and *time* when calculating *velocity* . | Velocity as a vector<br>uniform rectilinear motion<br>acceleration uniformly accelerated rectilinear motion<br>vertical and horizontal throw | 50 | Learner experiments<br>presentation | *Road experiment with CASSY, catapult-project*<br><br>*Optional:*<br>*circular motion with constant angular velocity*<br>*centripetal force*<br>*Newton's Law of Gravity*<br>*applications*<br>*angular momentum (-conservation)*<br>*<u>qualitative</u>* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (4) describe motion-charts orally<br><br>(5) describe *acceleration* verbally | (4) describe motion-charts orally<br><br>(5) describe *acceleration* as a measure of change of speed qualitatively | . $v = \frac{s}{t})$<br><br>(4) interpret motion graphs (*s-t graph, v-t graph*) and derive a *v-t-graph* from a *s-t-graph*<br><br>(5) describe *acceleration* as a measure of change of speed qualitatively | | | | |
| **10.2** | **Dynamics/Statics** | | | | | | |
| | **Content-related skills**<br><br>**B** | **I** | **A** | **Contents (compulsory for the region)** | **Time in lessons** | **Methods curriculum** | **School-specific supplements and additions** |
| | (1) derive rules for save behavior in traffic from their knowledge of mechanics (e.g. safety belts) | (1) derive rules for save behavior in traffic from their knowledge of mechanics (e.g. safety belts) | (1) derive rules for save behavior in traffic from their knowledge of mechanics (e.g. safety belts) | Weight force<br>Force as a vector<br>Addition and resolution of forces<br>Static equilibrium condition<br>Newton's law<br>dynamic equilibrium condition of forces,<br>momentum and momentum conservation, | 50 | Group-puzzle, learner experiments, work with models | *Combination of energy- and momentum conservation* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | energy,<br>labor and<br>momentum,<br>elastic and inelastic<br>collisions | | | |
| **10.3** | **Thermodynamics** | | | | | | |
| | **Content-related skills**<br><br>**B** | **I** | **A** | **Contents (compulsory for the region)** | **Time in lessons** | **Methods curriculum** | **School-specific supplements and additions** |
| | (2) describe, that in real energy conversions some of the energy is converted into thermal energy<br><br>(3) describe the effect of carbon dioxide as a greenhouse gas<br><br>(4) apply their Physical knowledge | (1) calculate the energy demand for heating water<br><br>(2) describe, that in real energy conversions some of the energy is converted into thermal energy<br><br>(3) describe the effect of carbon dioxide as a greenhouse gas<br>(4) apply their Physical knowledge | (1) describe the change of thermal energy when temperature changes<br><br>(2) Describe the difference between *reversible* and *irreversible* processes<br><br>(3) describe the effect of carbon dioxide as a greenhouse gas<br><br>(4) apply their Physical knowledge | Absolute temperature<br>gas laws<br>entropy<br>laws of thermodynamics<br>heat transfer | 20 | Learner experiments, presentation, work with tables and diagrams | *only qualitative considerations of ordered and unordered systems* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | to describe *natural* and *anthropogenic greenhouse effect*<br><br>(5) apply their Physical knowledge to use energy carefully and efficiently (e.g. climate protection, sustainability, economy) | Apply knowledge to describe *natural* and *anthropogenic greenhouse effect*<br><br>(5) apply their Physical knowledge to use energy carefully and efficiently (e.g. climate protection, sustainability, economy) | to describe *natural* and *anthropogenic greenhouse effect*<br><br>(5) apply their Physical knowledge to use energy carefully and efficiently (e.g. climate protection, sustainability, economy) | | | | |

# Commands for Grade 9

| | |
|---|---|
| **Specific requirements I** | |
| **set up** | arrange and combine objects and devices appropriately |
| **calculate** | mathematical determination of a result |
| **describe** | express structures, situations, processes and properties of objects generally by using technical terms |
| **create (diagrams)** | express correlations between variables in a coordinate system |
| **name/label** | list elements, situations, concepts, data without explanations |
| **outline** | basic representation of situations, objects, structures or interrelations |
| **Specific requirements II** | |
| **derive** | reasonable conclusions based on findings |
| **apply** | refer a known correlation or known method to a different situation |
| **determine** | generate a result mathematically, graphically or experimentally |
| **explain** | Capture structures, processes, correlations etc. of a situation and ascribe to general statements/laws . |
| **classify** | assign concepts, objects etc. to given criteria on the basis of certain characteristics |
| **measure** | determine experimental data under consideration of measurement rules |
| **investigate** | targeted exploration of situation and objects, identify features and correlations |
| **compare** | Identify similarities and differences |

| Specific requirements III | |
|---|---|
| **evaluate** | Founded assessment of a situation according to scientific or methodological criteria or to personal- and social values. |
| **explain** | Capture structures, processes, correlations etc. of a situation and attribute to general statements/laws and make them understandable by additional information or examples |
| **interpret** | Examine and assess situations and correlations in regard to explanation possibilities |

# Commands for Grade 10 (according to BLASchA)

| **Operator** | **Command term** | | | | |
|---|---|---|---|---|---|
| | | | | | II. |
| abschätzen *(nur Physik und Biologie*) | estimate | durch begründete Überlegungen Größenordnungen angeben | find an approximate and reasonable value for an unknown quantity | Estimate whether a 10A fuse would be sufficient in the given situation. | II. |
| analysieren | analyse and identify | systematisches Untersuchen eines Sachverhaltes, bei dem Bestandteile, deren Merkmale und ihre Beziehungen zueinander erfasst und dargestellt werden | investigate phenomena/data/etc. systematically considering and representing parts/features and relationships/connections | Analyse the setup of the experiment and identify possible sources of errors. | II. |
| . | apply | einen bekannten Zusammenhang oder eine bekannte Methode auf einen anderen Sachverhalt | use a known idea, equation, principle, theory or law in a new situation | Apply the induction law to the situation given. | II. |
| Aufstellen von Hypothesen | propose a hypothesis | eine begründete Vermutung formulieren | suggest or construct a clearly focused and justi- fied assumption | Propose a hypothesis looking at the different Physical quantities affecting the magnetic flux density of a sole- noid. | III |
| auswerten | evaluate | establish a connection between data, individual results and other elements and combine to formulate an overall assessment. | process data and results, deduce a relationship between the variables, conclude general state- ments and assess the implications | Evaluate the experiment's magnetic flux density of a solenoid and state the derived equation. | III |
| begründen | justify/give reasons | Sachverhalte auf Regeln, Gesetzmäßigkeiten bzw. kausale Zusammenhänge zurückführen | put phenomena down to underlying rules, (physi- cal) laws and causal relationships | Justify/Give reasons why the red line of the hydrogen spectrum causes no photo effect. | III |
| benennen | name/label | Begriffe und Sachverhalte einer vorgegebenen Struktur zuordnen | assign the specific terms to a given structure | Name the parts of the X-ray tube. | I |
| berechnen | calculate | Ergebnisse aus gegebenen Werten rechnerisch generieren | insert the corresponding values into an equation and generate the result | Calculate the gravitational field strength at the equator using the mean radius of the earth and the earth medium density. | II. |
| . | describe | Sachverhalte wie Objekte und Prozesse nach Ordnungsprinzipien strukturiert unter Verwendung der Fachsprache wiedergeben | give a detailed and structured description of something using the appropriate terminology | Describe the setup of the Milikan experiment and how it is conducted. | II. |
| bestimmen | find | Ergebnisse aus gegebenen Daten generieren | generate a result from data given (graphically or numerically) | Find the value of the Planck constant from the diagram. | II. |
| beurteilen, bewerten | comment on/assess | zu einem Sachverhalt eine selbstständige Einschätzung nach fachwissenschaftlichen und fachmethodischen Kriterien angeben | pass judgment on something based on scientific criteria/methods | Comment of the use of Carbon dating for age determination in the following situation. | III |
| beweisen *(nur Physik und Biologie* | show/reason | mit Hilfe von sachlichen Argumenten durch logisches Herleiten eine Behauptung/Aussage belegen bzw. | prove something by means of factual argumenta- tion/reasoning by logic deduction | Show that Bohr's and De Broglie's approaches lead to the same quantum condition. | III |

# Performance assessment

## Assessment criteria and references for verification of learning achievements

Assessment criteria in Grades 7 and 8 in the subject Physics, are based on the different competency areas. These include methodological skills, knowledge acquisition, communication by means of technical terms and evaluation.

A differentiated assessment of learner performance is ensured by development of uniform and transparent learning evaluation criteria. Work processes (e.g. by observing learning behavior and group procedures), as well as written and oral performance in class tests, short tests, presentations, oral participation and projects, are evaluated. In addition, the learners' individual learning process is taken into account in performance evaluation. Sound terminology skills and compliance with standard linguistic norms and formal aspects are also regarded in the performance evaluation.

Teamwork, expedient problem awareness, methodological security, information acquisition and processing, independence and presentation of results are evaluated under methodological skills. In scientific knowledge acquisition, mainly scientific propaedeutic working techniques are of great significance. Learners should also be able to pass a reflected judgment. Substantiation and multiple perspectives or controversy in argumentation play a key role here.

Written performance evaluation in the junior section (Grades 7 and 8) is based on class work. Oral performance is determined by quality of participation in class (also in group- and project work), presentations and quality of homework. One class test per trimester is given in Grades 7 and 8. The written mark counts 50% of the final mark.

The following aspects are particularly important in determination of the oral and written mark:

- technical correctness
- confidence in using technical language and methods of a subject
- correct succession, substantiation, logical association of statements
- Complexity factor, multi-perspectivity or controversy in argumentation
- extent of independence
- conceptual clarity
- compliance with standard linguistic norms and formal aspects

# Internal differentiation

Due to two co-existing school leaving certificates, the NSSC and the DIAP, as well as high numbers of different languages and ethnic groups at our school, differentiated lessons are essential. In no grade, in no class and nearly in no course at the DHPS, equal conditions can be expected; therefore internal differentiation is the minimum prerequisite that should be met to satisfy the learners' needs.

Physics of course is no exception in this regard. Therefore neither the experience of a river flowing, wave motions in the ocean or the fascination of libraries can be taken as granted, nor can the knowledge of centrifuges, trams or a harvester be seen as a prerequisite.

Even the level of the official language, English, offers an enormous spectrum, so that learning prerequisites are very heterogeneous among learners of our school.

All these facts imply that DHPS teachers need to have a wide repertoire of internally differentiated methods at their disposal to face the daily challenges.

# Examples of tasks

Listed below are examples of tasks for class tests or exams. For up to and including Grade 10, the respective maximum possible points are shown for better orientation for the learners. As from Grade 7, operators (see pg. 17) are used to familiarize learners at an early stage with the meaning thereof, i.e. with the different requirement levels.

**Grade 9**

1. State, the number of protons, neutrons and electrons of the neutral atoms, whose nuclei are represented by the following symbols:
   ${}^{4}_{2}He$;. ${}^{2814}Si$; ${}^{9038}Sr$; ${}^{197}{}_{79}Au$; ${}^{201}{}_{80}Hg$ and ${}^{239}{}_{94}Pu$ **12**

2. Draw the international symbol for radioactivity. **2**

3. During transformation of nuclei, nuclear radiation can be emitted. Describe how a nucleus changes during radiation of α-, β- und γ-radiation. **3**

**Grade 10**

Problem 3: Heat

3.1. In the kitchen you find various objects that are good or bad heat conductors. Name three of each and discuss their advantages. **6**

3.2. Explain why large inland waters such as Lake Michigan in the USA can be quite chilly in early July despite the outdoor air temperatures being near or above 90°F (32°C). **3**

3.3. An 11,98 g sample of zinc metal is placed in a hot water bath and warmed to 78.4°C. It is then removed and placed into a Styrofoam cup containing 50 ml of water at room temperature (T = 27°C). The water warms up to a temperature of 28,1°C. Determine the specific heat capacity of the zinc. **5**